City of Salinas

Development Standards Plan Low Impact Development Designs and Practices for Urban Storm Drainage Management

June 2007 DRAFT

California Environmental Protection Agency
CENTRAL COAST REGIONAL
WATER QUALITY CONTROL BOARD

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Section 1: Introduction

1.0 Purpose and Organization

The purpose of the City of Salinas Development Standards Plan (Salinas DSP) is to present Low Impact Development (LID) planning policies, procedures and design standards that will effectively reduce the volume, rate, and pollutant loading of urban runoff from new development and significant redevelopment in the City and throughout the central coast region. The LID practices presented in the Salinas DSP have been carefully selected to provide a variety of design concepts applicable to the various land uses and climatic zones of the region. The Central Coast Regional Water Quality Control Board (RWQCB) facilitated and funded the development of the Salinas DSP under National Fish and Wildlife Foundation Contract No. 98-289-21. The development and implementation of the Salinas DSP is a requirement of Attachment 4 to RWQCB Order R3-2004-0135 (National Pollutant Discharge Elimination System (NPDES) Permit No. CA0049981) dated 4 February 2005, hereinafter referred to as the Salinas NPDES Permit.

The Salinas DSP is intended to assist planners, developers, engineers, architects, landscape professionals, City staff (development planning, permitting, engineering, parks, and maintenance), City planning commissioners, and others with the selection, siting, design, operation and long-term maintenance of LID practices and structural treatment controls for improving the quality and reducing the quantity of urban runoff and storm water discharges to local creeks, wetlands and rivers. As discussed in the following sections, LID practices and structural treatment controls are storm water Best Management Practices (BMPs) designed to treat the amount of runoff produced by the most frequently occurring, relatively small storm events. Therefore, conventional storm drainage facilities must also be included in development projects for the purpose of conveying the larger quantities of runoff that occur from larger storms to prevent flooding.

In addition, the Salinas DSP provides guidance on the policies and procedures that have been developed to meet the Salinas NPDES Permit requirements. Emphasis is placed on design of features and practices that mimic natural hydrologic functions (e.g. LID practices). These include design practices that minimize and disconnect impervious surfaces and facilities that filter runoff through vegetation, soils and organic matter. LID practices capture, slow, and cleanse urban runoff, enhance evapotranspiration, allow biodegradation of pollutants by soil bacteria, and increase infiltration and groundwater recharge where existing site soils permit these processes. Conventional development and storm drain system designs typically inhibit natural hydrologic functions by creating large areas of impermeable surfaces that prevent infiltration and recharge, increase runoff, provide surfaces for pollutants to accumulate and include pipelines that quickly transport pollutants to streams, rivers, lakes, wetlands and the ocean (e.g. the Monterey Bay National Marine Sanctuary).

LID designs and practices can be applied to most areas of residential, commercial, industrial, and municipal development. LID practices such as vegetated swales and bioretention systems can be incorporated anywhere landscaping occurs in urban development. If designed correctly, these LID practices can be a key amenity for the property, providing both aesthetic qualities and functional storm water management benefits. There are numerous variations of LID designs that can be incorporated into development and redevelopment projects. Therefore, planning and design professionals and City staff should seek additional training and reference additional

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guidance documents and sources of information, such as those provided in the Salinas DSP. They should share their design and construction experiences with others in the local development community to improve the success and effectiveness of future projects.

Most LID practices should involve landscape architects and these professionals should be involved in all phases of project planning and design, especially during the conceptual design phase. LID cannot be effectively implemented into development projects if landscape architects are only involved during the final design phase (which is often the case). Landscape architects can be particularly important in redevelopment projects because they are trained not only in the science and aesthetics of plants in urban areas, but they are one of the few professions that can create functional landscaping (e.g. LID) in areas with numerous physical constraints.

Community participation in the planning and construction of LID practices, particularly at redevelopment projects, can also greatly add to the long-term success of a project and increase public awareness of the need to effectively manage storm water quantity and quality. In addition, art installations, public education signs and placards at LID demonstration project sites can also provide additional benefits. A simple art installation designed to capture and convey storm water to a LID treatment system can help the public understand that runoff can be a beneficial resource that can be used to help reduce dependence on potable water for irrigation (in addition to reducing untreated urban runoff from entering the conventional storm drain system and discharging to a nearby stream).

The Salinas DSP is organized as follows:

- Section 1 provides the purpose and organization of the Salinas DSP, its development history, related NPDES permit regulations, the new Salinas development review process, the Salinas DSP program area, documents related to the Salinas DSP, and the process to update and revise the Salinas DSP and provide comments to the City.

- Section 2 provides a general discussion on Low Impact Development (LID) and identifies LID policies and practices that meet the Maximum Extent Practicable (MEP) definition, and those that do not. This section also discusses the benefits and advantages of LID and several key storm water management/LID concepts such as the definition of BMPs, MS4 and MEP, what constitutes Impervious Surfaces, and what are Storm Water Quality Design Storms, Infiltration, Percolation, Amended and Engineered Soils.

- Section 3 presents several LID planning techniques that should be considered in the preliminary design phase of new development projects. This section also provides design information and examples of the techniques that can be used to minimize and disconnect impervious surfaces. Detailed information is also provided on the siting, design, inspection and maintenance requirements of LID practices such as vegetated swales, bioretention systems, permeable pavements and other techniques. Several examples of the experiences other communities have had implementing similar LID practices are also provided.

- Section 4 presents information on LID design considerations such as estimating pollutants loads from urban development, shallow soil and groundwater conditions in the Salinas area, guidance on the design and selection of structural treatment control BMPs, an LID practice planting guide, and the NPDES permit required numeric sizing criteria that must be applied to flow and volume-based structural treatment control BMPs. Design guidance is also provided for diversion structures for structural treatment control BMPs. In addition, examples of the LID practices that can be applied to Prority Project Categories is provided. Additional information is also presented regarding design considerations to prevent groundwater contamination, storm water in crawl spaces, mosquito breeding, and slope failures.

- Section 5 presents general information on related source and structural treatment control BMPs for new development and significant redevelopment. This section primarily discusses the related public domain structural treatment control BMPs that can be used with LID practices to meet the NPDES permit required MEP standard. A brief discussion about manufactured (patented) structural treatment control BMPs is also included. However, when used alone, most manufactured systems do not meet the MEP standard.

- Section 6 presents a compilation of the references and additional resource information provided throughout the Salinas DSP. To ensure the success and widespread implementation of LID, planning and design professionals and City staff should seek additional training and reference additional guidance documents and sources of information during the planning, design, construction and maintenance of development projects.

- Appendix A provides a copy of the section of the Salinas NPDES Permit that provides storm water requirements for new development and significant redevelopment in the City (Attachment 4 to RWQCB Order R3-2004-0135).

- Appendix B provides a Model LID Ordinance for Salinas and the Central Coast.

- Appendix C provides examples of LID practice design calculations.

- Appendix D provides a Glossary of the technical/regulatory terms used in the Salinas DSP.

- Appendix E provides a List of Acronyms.

1.1 State Water Board's LID Policy

On January 20, 2005, the State Water Resources Control Board (SWRCB) adopted sustainability as a core value for all activities and programs of California's nine RWQCBs. The SWRCB also directed the California RWQCBs' staff to consider sustainability in all future policies, guidelines, and regulatory actions.

Per the SWRCB, Low Impact Development (LID) is a sustainable practice that benefits water supply and contributes to water quality protection. Unlike traditional storm water management, which collects and conveys storm water runoff through storm drains, pipes, or other conveyances to a centralized storm water facility, LID takes a different approach by using site design and storm water management to maintain the site's pre-development runoff rates and volumes. The goal of LID is to mimic a site's predevelopment hydrology by using design techniques that infiltrate, filter, store, evaporate, and detain runoff close to the source of rainfall. LID has been a proven approach in other parts of the country and is seen in California as an alternative to conventional storm water management. The RWQCBs are advancing LID in California in various ways:

- Regulation through site-specific and general permits;

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- Providing advocacy and outreach to local governments through the RWQCBs' Training Academy and regional workshops;

- Researching how to incorporate LID language into Standard Urban Storm Water Mitigation Plan (SUSMP) requirements;

- Funding LID related projects through the consolidated grants program; and

- Funding through CWA 319 funds to provide for further researching applicability of Impervious Surface Analysis Tool (ISAT) for land use planners and for the California Water and Land Use partnership (CaWaLUP) Center at U.C. Davis.

The SWRCB and the RWQCBs are key partners of the CaWaLUP (http://cawalup.usc.edu/), a collaborative effort made up of representative staff from government agencies, non profits, and academia, which aims to improve how water resource implications of land use are considered in California's local government decisions.

1.2 NPDES Storm Water Permit Regulations

Implementation of National Pollutant Discharge Elimination System (NPDES) Storm Water Permit regulations is mandated under both federal and state regulations (the U.S. EPA, the SWRCB, and the RWQCB). In 1987, Congress amended the Federal Water Pollution Control Act (also known as the Clean Water Act) in order to protect receiving water bodies from the impacts of urban runoff. The amendments established a framework for regulating municipal and industrial storm water discharges under the NPDES. According to the Clean Water Act mandate, municipalities regulated under the NPDES must reduce pollutant loadings in municipal separate storm sewer systems (MS4s) to the "maximum extent practicable" (MEP) and must effectively prohibit non-storm water discharges through their MS4s as a first step toward achieving pollutant loading reductions consistent with applicable water quality standards (U.S. EPA, 1997). Widespread implementation of storm water best management practices (BMPs) is required to meet the MEP standard. Detailed definitions of what constitutes an MS4, the various types of storm water BMPs, and the MEP standard are provided in Section 2.5 of the Salinas DSP.

The Central Coast RWQCB is the lead state agency responsible for protecting water quality in the Central Coast Region of California. The RWQCB has the authority to enforce regulatory policies and statutes under the Clean Water Act, the California Porter-Cologne Water Quality Control Act and the Central Coast Regional Water Quality Control Plan.

The following discussion presents a summary of Attachment 4 to the Salinas NPDES Permit (presented in Appendix A). For convenience, simplified explanations of some of the regulatory/statutory text provided in the permit have been provided. In the event of a conflict, the text and definitions found in the Salinas NPDES Permit take precedence.

The primary requirement of the Salinas NPDES Permit is the effective reduction in the volume, rate and pollutant loading of urban runoff draining to the City's municipal storm drain system (MS4) and discharging to receiving water bodies. With respect to new development and significant redevelopment in the City, Attachment 4 to the Salinas NPDES Permit requires that short and long-term water quality impacts on receiving waters be minimized through the City's review and update of its existing planning and development program. Per Attachment 4 the City is required to implement the following measures:

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1. Require developers to analyze pre-and post-project pollutant loads and peak flow rates, and identify the Best Management Practices (BMPs) to be implemented;
2. Describe the BMPs that can be used in a Development Standards Plan (DSP);
3. Review and condition for compliance all “Priority Project Categories” and require the incorporation of structural treatment control BMPs and non-structural BMPs (source controls) as necessary to mitigate the projected increases in pollutant loads and peak flow rates;
4. Minimize the amount and direct connection of impervious surfaces;
5. Infiltrate runoff on-site where appropriate soil conditions exist and where infiltration of storm water will not pose a potential threat to groundwater quality;
6. Implement pollution prevention and source control measures as a first line of defense;
7. Preserve, create or restore riparian corridors, wetlands and buffer zones;
8. Implement structural treatment controls where necessary and where pollution prevention and source control measures are not sufficient to protect receiving water quality.

<u>Priority Project Categories</u>

Per Section III of Attachment 4 to the Salinas NPDES Permit (Appendix A), the City of Salinas is required to implement practices and policies that minimize the short and long-term impacts on receiving water quality from new development and significant redevelopment (defined as the creation or addition of at least 5,000 square feet of impervious surfaces on an already developed site). Specifically the City must review and condition for compliance the following Priority Project Categories:

1. Residential developments with 10 or more units;
2. Commercial developments that create 100,000 ft^2 or more impervious land area;
3. Automotive repair shops (≥ 5,000 ft^2);
4. Restaurants (≥ 5,000 ft^2);
5. Hillside developments (≥ 5,000 ft^2);
6. Parking lots (≥ 5,000 ft^2);
7. Streets, roads, highways, and freeways that create 5 or more acres of pavement; and,
8. Retail gasoline outlets (≥ 5,000 ft^2)

As noted above, these Priority Project Categories are required to incorporate structural treatment control BMPs and non-structural BMPs (source controls) as necessary to mitigate the projected increases in urban runoff pollutant loads, flow rates and volumes.

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For additional details on Priority Project Categories, please reference the Salinas NPDES Permit in Appendix A.

Numeric Sizing Criteria

The Salinas NPDES permit requires the application of numeric sizing criteria to the volume- and flow-based treatment control BMPs proposed for any of the above Priority Project Categories. The required numeric sizing criteria is discussed in detail in Section 4.4 of the Salinas DSP.

Pollutants of Concern

When selecting structural treatment control BMPs, planners and designers of Priority Project Categories must consider the following:

1. Target pollutants;

2. Pollutants associated with different land uses;

3. Post-development changes in runoff volumes and flow rates; and

4. Sensitivity of receiving waters to changes in runoff volumes and flow rates and the potential for downstream erosion and stream habitat degradation.

Local pollutants of concern include:

- Fecal Coliform and Nitrate (per 303(d) list);

- TDS, Cl, CO_4, B and Na (per Water Quality Objectives for the Salinas River and the Gabilan Tributary, Central Coast Regional Water Quality Control Plan, 1994); and,

- Sediment from construction sites

General urban pollutants of concern that may be contained in storm water include heavy metals; pathogens; petroleum hydrocarbons; polycyclic aromatic hydrocarbons (PAHs), trash, pesticides, herbicides, and nutrients that cause or contribute to the depletion of dissolved oxygen and/or impaired conditions in receiving water quality. Increased flows from urban development may cause or contribute to downstream erosion and/or excessive sediment discharge and deposition in receiving waters. Additional information about common sources of urban storm water pollutants and estimating pollutant loads is presented in Section 4.0 of the Salinas DSP.

Potential Impacts on Groundwater Quality

Planners and designers of Priority Project Categories must also consider potential impacts on groundwater quality if direct or indirect storm water infiltration facilities are proposed. Restrictions on these structural treatment control BMPs include the following:

- Storm water infiltration practices must not to be used in drainage areas that include industrial or commercial sites with outdoor storage of materials and/or chemicals;

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- Existing site soil infiltration rates must be tested and yield percolation rates of at least 0.5 inches/hour, but not be greater than 3.0 inches/hour (120 to 20 minutes/inch).

- There must be a minimum separation of 5 feet between the bottom of a proposed storm water infiltration practice and the seasonally high groundwater level.

- Storm water infiltration practices must be located at least 100 feet from drinking water supply wells; and,

- Storm water infiltration practices must be located at least 500 feet from underground storage tanks (UST's) and areas of known groundwater contamination, such as the Leaking Underground Fuel Tank (LUFT) sites.

Additional design criteria and potential setback exemptions for storm water infiltration practices are presented in Sections 4.2, 4.4, and 4.8 of the Salinas DSP.

<u>Maintenance Agreements</u>

Priority Project developers and land owners must also establish maintenance agreements for post-construction structural treatment control BMPs and ensure the transfer of maintenance responsibilities occurs when land ownership changes occur. The City of Salinas shall require verification of maintenance provisions for structural treatment control BMPs by implementing the following measures:

1. Developers must sign a statement accepting responsibility for maintenance until the maintenance responsibility is legally transferred to another party; or

2. Written conditions must be included in the sales or lease agreement that require the recipient to assume responsibility for maintenance; or

3. Written text must be included in project conditions, covenants and restrictions (CC&R's) for residential developments that assign maintenance responsibilities to a home owner's association (HOA), or another appropriate group, for the maintenance of structural treatment control BMPs; or

4. Implementation of any other legally enforceable agreement that assigns responsibility for maintenance of structural treatment control BMPs.

The City of Salinas will utilize Maintenance Assessment Districts to ensure the long-term regular maintenance of structural treatment control BMPs located on private property. Maintenance Assessment Districts are currently used by private property owners to fund storm drain system maintenance, including detention/retention ponds.

<u>Waiver Program & Regional Storm Water Mitigation Fund</u>

The City may propose a waiver program and/or a regional storm water mitigation fund with the approval of the RWQCB. The waiver program could potentially allow for a project to be waived from requirements to implement LID practices and structural treatment control BMPs if infeasibility can be established. A regional or sub-regional storm water mitigation program could potentially substitute in part or wholly for the Development Standard requirements noted above. The RWQCB may consider for approval such a program if its implementation will:

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1. Improve storm water quality and protect stream habitat;

2. Promote cooperative problem-solving by diverse interests;

3. Be fiscally sustainable via secured funding; and,

4. Be completed in five years, including the construction and start-up of treatment facilities.

Additional details and requirements for establishing a Waiver Program and a Regional Storm Water Mitigation Fund are presented in Sections III d. and e. of Attachment 4 (Appendix A).

1.3 Salinas Development History

The City has experienced significant new development in the past several years. There are several large developments planned for the northern and eastern areas of the City. These large developments pose both water quality challenges and opportunities with respect to LID. Current agricultural land uses can negatively impact water quality through soil loss, fertilizer use, and pesticide/herbicide application. Conversion to urban land uses has the potential to improve some of these water quality concerns such as a reduction in soil erosion. However, urban land uses can pose different water quality challenges. As discussed in Section 4.0 of the Salinas DSP, a wide variety of pollutants can be deposited on manmade impervious surfaces and incorporated into urban runoff that enters the storm drain system and discharges into local waterways. Through the use of LID techniques, it is intended that net water quality impacts from these new development areas are reduced.

As noted above, the RWQCB is the lead state agency responsible for protecting the water quality of the Central Coast Region. To protect the receiving waters of the Salinas area, the RWQCB has required the City to develop and submit for public review and comment, and RWQCB approval, the Salinas DSP. This document is intended to describe the source control and structural treatment control BMPs that are to be implemented at all new development and significant redevelopment projects in the City that fall under the Priority Project Categories noted above. LID designs and practices can serve as both source and structural treatment control BMPs. Section 2.5 of the Salinas DSP provides a detailed discussion about the concept of BMPs and the range of BMPs that must be implemented to meet the required MEP standard.

Development of the Salinas DSP began in May 2006. Kennedy/Jenks Consultants met with RWQCB and City staff to exchange information and develop an approach and schedule to complete the Salinas DSP. Technical memoranda were developed and public workshops were presented to facilitate public education and participation. Draft and final technical memoranda were developed on the following subjects:

1. Review of City of Salinas Policies and Procedures for Conformance with LID Principles and NPDES Permit Requirements;

2. Review of Surface Soil and Shallow Groundwater Conditions and the Feasibility of Infiltrating Urban Runoff in the Salinas Area; and,

3. Model Low Impact Development (LID) Ordinance for Salinas and the Central Coast.

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The final technical memoranda formed the basis for the development of the Salinas DSP. The workshop presentations have been posted on the RWQCB's website (http://www.swrcb.ca.gov/rwqcb3/SWNEW/PhaseI/Municipal/index.htm).

1.4 Salinas Development Review Process

The Salinas NPDES Permit requires the Priority Project Categories noted above to meet specific standards. These include the incorporation of storm water BMPs to protect receiving water bodies from increased pollutant loads and increases in the rate and volume of runoff. The City's development review process for storm water BMPs relates to project design, environmental review, permit conditions, and construction management. The type and location of storm water BMPs are site and project specific; therefore, they will vary based upon the project's design and the potential impact to urban runoff and receiving water quality.

The following presents the Salinas Development Review Process for Priority Project Categories.

Step 1 – Conceptual Project Development Process: Development processing begins with land use review by the City's planning staff. For relatively large or complex projects, and for applicants new to the process, a pre-application meeting is an advisable first step. As NPDES storm water management requirements and BMPs such as LID practices are new to the City and the public, a pre-application meeting is recommended for all Priority Project Categories until procedures are well established. Staff will review proposed land uses, discuss site constraints, opportunities, and necessary BMPs (as well as other requirements) and potential design options. Additional information will be provided to applicants as needed. The pre-application meeting affords early dialogue about project opportunities and constraints, and can avoid unnecessary delays.

As of 2006, the City required the submittal of a draft Storm Water Control Plan as part of the initial step for planning and zoning review. In addition to presenting design concepts and BMPs to reduce the volume, rate and pollutant loading of runoff from the proposed development, the benefits of submitting a Storm Water Control Plan during planning and zoning review potentially include:

- Reduced overall project costs,
- Expedited project review,
- Improved site design,
- A cost effective approach to achieving the Salinas NPDES Permit required MEP standard, and
- Avoiding unnecessary site redesign and project delays.

As noted in Section 1.0, applicants proposing to construct projects should consider involvement of landscape design professionals during the conceptual design phase as well as later phases of the project. Landscape architects can assist with the siting and preliminary design of LID practices which are most effective when considered early in the development process.

Step 2 – Planning Permit Process: Once the project application is deemed complete, City planning staff will review the proposed development for conformity with City codes, ordinances, and standards, and related state and federal requirements. They will solicit comments from other municipal departments such as fire, police, water resources, and others. Comments from these various municipal disciplines will be considered and selected projects will be discussed at a Design Review Committee (DRC) meeting. DRC recommendations may result in project amendments or Conditions of Approval (COA's). Projects requiring post-construction structural treatment control BMPs shall be recommended for approval only after all applicable requirements have been satisfactorily incorporated in project plans (including the draft Storm Water Control Plan), specifications and permit conditions. Applicable projects will be required to include the environmental review procedure prescribed under the California Environmental Quality Act (CEQA). City planners will review the applicant's draft Storm Water Control Plan as part of the CEQA environmental review process.

Requirements to implement BMPs will be based upon a determination of the potential for significant adverse impacts to: 1) water quality and 2) ambient flow volumes and velocities to downstream beneficial uses, or municipal/county storm drain systems. When City planners determine that potentially significant impacts are present, they will require that mitigations, and project conditions including BMPs to reduce impacts to "acceptable levels" be added. "Acceptable levels" are defined as levels that conform to the Salinas General Plan, the State Basin Plan, the Salinas NPDES Permit, and the Salinas Storm Water Management Plan. If potential significant impacts are present and can not be easily mitigated; City staff may require preparation of an Environmental Impact Report (EIR) per CEQA regulations.

Step 3 – Building Permit Process: During the building plan, construction permit, and plan check process, City staff will review non-discretionary and previously approved discretionary projects for adequacy of land planning and development (post-construction) BMPs. City staff will ensure that storm water BMPs included under planning review are carried forth and incorporated into construction drawings/plans, specifications and conditions (and the final Storm Water Control Plan). In addition, City staff will identify needs and add other storm water BMPs as needed to meet erosion control, engineering, or other Salinas NPDES Permit requirements. Changes to the project post-discretionary approval will also be reviewed. During this phase of the project, long-term post-construction BMP inspection, operation and maintenance policies and procedures will be established. Maintenance methods and responsibilities must be identified in writing and approved as part of permit conditions prior to permit issuance. In addition, the mechanism(s) necessary to assure the maintenance of construction and/or post-construction BMPs must be fully executed prior to the commencement of construction.

Step 4 – Post Construction: Project applicants will assure the adequacy of the inspection, operation and maintenance of permanent storm water BMPs during construction and throughout life of project. Maintenance of structural treatment controls and other storm water controls will be the responsibility of the property owner, unless an alternative agreement is formally approved by the Director of Maintenance Services. The City may consider in-lieu maintenance provisions, such as payment of a perpetual fee in an amount sufficient to cover full maintenance cost. Such transfer requests shall include an itemized cost analysis signed by the applicant (or their agent). Full cost recovery shall include an escalation provision to reflect inflationary effects. Adequacy of assurance will be determined by staff and may include the posting of performance bonds, construction details, site management BMPs and/or other means.

Where post-construction storm water BMPs are not maintained and they become a public health and safety hazard and/or a source of storm water pollution, the City will consider enforcement and penalty procedures such as fines and/or referral to the Monterey County Health Department

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and the RWQCB. The City may also conduct the necessary corrective actions and take legal actions against the property owner to recover the costs.

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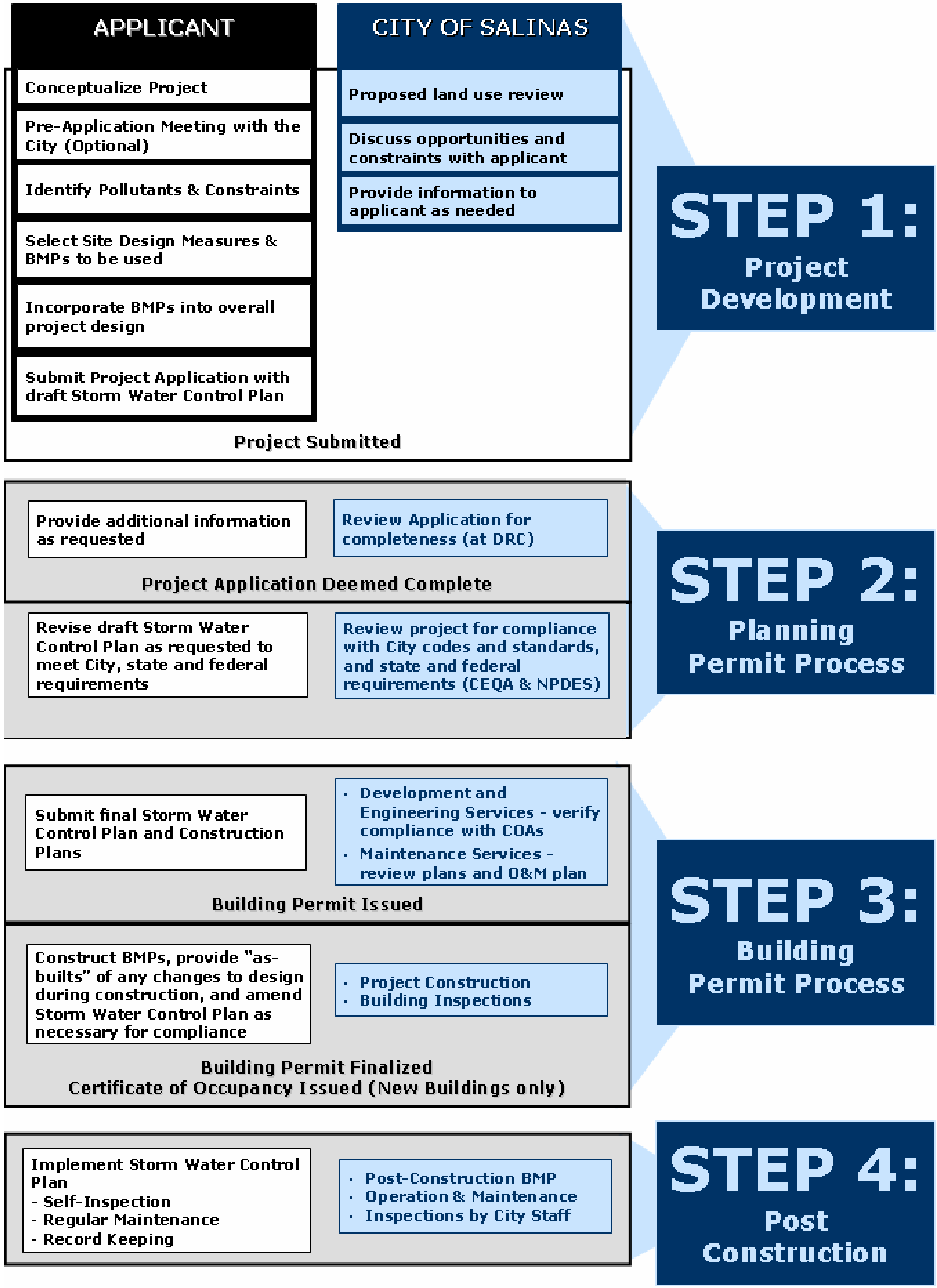
APPLICANT
CITY OF SALINAS
Conceptualize Project
Pre-Application Meeting with the City (Optional)
Identify Pollutants & Constraints
Select Site Design Measures & BMPs to be used
Incorporate BMPs into overall project design
Submit Project Application with draft Storm Water Control Plan
Proposed land use review
Discuss opportunities and constraints with applicant
Provide information to applicant as needed
Project Submitted
STEP 1: Project Development
Provide additional information as requested
Review Application for completeness (at DRC)
Project Application Deemed Complete
Revise draft Storm Water Control Plan as requested to meet City, state and federal requirements
Review project for compliance with City codes and standards, and state and federal requirements (CEQA & NPDES)
STEP 2: Planning Permit Process
Submit final Storm Water Control Plan and Construction Plans
Development and Engineering Services - verify compliance with COAs
Maintenance Services - review plans and O&M plan
Building Permit Issued
Construct BMPs, provide "as-builts" of any changes to design during construction, and amend Storm Water Control Plan as necessary for compliance
Project Construction
Building Inspections
Building Permit Finalized
Certificate of Occupancy Issued (New Buildings only)
STEP 3: Building Permit Process
Implement Storm Water Control Plan
- Self-Inspection
- Regular Maintenance
- Record Keeping
Post-Construction BMP
Operation & Maintenance
Inspections by City Staff
STEP 4: Post Construction

The Regional Board and/or the City should consider developing guidance on completing a Storm Water Control Plan, including related checklists and potentially a model plan presented in the appendices. The term "Project Specific SWMP" presented in the Model LID Ordinance in Tech Memo No. 3 has been replaced with "Storm Water Control Plan" in the Model LID Ordinance included in appendices of the Salinas DSP for consistency and to reduce potential confusion with the City of Salinas SWMP.

1.5 Salinas DSP Program Area

The Salinas DSP applies to areas of new development and redevelopment within the City of Salinas that fall under the Priority Project Categories noted in Section 1.1 above. Per the Salinas NPDES Permit, the receiving waters subject to municipal storm water discharges in the City include Santa Rita Creek, Gabilan Creek, Natividad Creek, Alisal Creek and their tributaries. Alisal Creek is renamed the Reclamation Ditch within the City. These receiving waters discharge to Espinosa and Tembladero Sloughs which in turn discharge to the Old Salinas River. Storm water from the southernmost portion of the City discharges to the main Salinas River channel, via a lift station. The main Salinas River, Espinosa and Tembladero Sloughs, discharge into the Old Salinas River channel which discharges to Monterey Bay.

1.6 Documents Related to the Salinas DSP

The Salinas DSP is intended to be used during the planning and design phase of new development and redevelopment projects in the City of Salinas. It should also be used as a general guidance document to assist owners with understanding the proper operation and long-term maintenance of their LID practices and structural treatment control BMPs. During the design of these facilities, the designer should cross-reference the City's current drainage design manual to ensure consistent technical approaches and related policies and procedures are applied. This information is currently contained in the following document:

- The City of Salinas Standard Specifications, Design Standards and Standard Plans

The other relevant documents that relate to the design and permitting of development and redevelopment projects, and associated drainage, flood control and storm water management facilities in the City of Salinas include the following:

- The City of Salinas Storm Water Ordinance
- The City of Salinas Zoning Code
- The City of Salinas Grading Ordinance
- The Salinas General Plan
- The City of Salinas Storm Water Management Plan

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The RWQCB requires the City to implement LID practices and structural treatment control BMPs that effectively reduce the volume, rate, and pollutant loading of urban runoff to the Maximum Extent Practicable (MEP). Since the science and technology of LID and structural treatment control BMPs is evolving and new and innovative BMPs continue to be developed, the City is required in its NPDES permit to periodically review and approve new or innovative BMPs to meet the MEP standard. New approved BMPs may be periodically added to the City's website (http://www.ci.salinas.ca.us/index.html). In addition, the City will review and update the Salinas DSP a minimum of once every five years. This schedule will ensure that the review and update process occurs at least once during each five-year NPDES storm water permit cycle. The review process should consist of two tasks; a technical review of the new LID practices and structural treatment control BMPs used locally, by other communities and recommended by the RWQCB and the U.S. EPA; and a procedural review of how well the Salinas DSP is being implemented in the City. Developers, planners, design engineers and contractors, as well as agency plan review, permitting, engineering and inspection staff should be consulted to determine potential deficiencies and suggested improvements.

1.□ Comments and Distribution

Comments and questions on the Salinas DSP may be directed to:

Mr. Carl Niizawa, P.E.,DEE
Deputy City Engineer
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Salinas, CA 93901-2639
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Fax: (831) 758-7935
Email: ***carln@ci.salinas.ca.us***

The City should decide if they want one person to be the point of contact for questions and comments (e.g. Carl) or if they want to provide general contact information (e.g. the DEE Department) in this section. This information should also be posted on the City's website when the Salinas DSP is posted.

1.□ Disclaimer

The City of Salinas Development Standards Plan (Salinas DSP) has been developed and reviewed using a high standard of professional care for identification of errors, omissions, and other related issues. As with the release of any new publication, it is likely that some nonconformities, errors or omissions will be discovered. The developers of the Salinas DSP welcome user feedback in helping to identify any problems so that improvements can be made to future releases. The user should refer to Section 1.7 above and check the City of Salinas website (http://www.ci.salinas.ca.us/index.html) for contact information to supply user feedback and information on updates and revisions to the Salinas DSP.

The Salinas DSP is intended to assist with the consistent design and review of Low Impact Development (LID) practices and structural treatment control BMPs to reduce pollutant loadings and the volume and rate of urban runoff to receiving waters such as Santa Rita Creek, Gabilan Creek, Natividad Creek, and Alisal Creek/Reclamation Ditch. The details and design standards

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provided in the Salinas DSP are intended to show design concepts. Preparation of final design plans, addressing details of structural adequacy, public safety, hydraulic functionality, maintainability, plant and soils specifications, and aesthetics, remain the sole responsibility of the designer. To be effective, it is recommended that LID practices and structural treatment control BMPs are planned and designed concurrently with conventional storm drainage and flood control facilities. Engineers and landscape architects are also encouraged to work together in the design of LID practices and structural treatment control BMPs that include soil amendments and vegetation (e.g. buffer strips, swales and bioretention basins) to effectively reduce the rate, volume and pollutant loading of urban runoff and that can serve to convey flows from large runoff events.

By use of the Salinas DSP the user agrees to the following:

1. The City of Salinas, its contractors, advisors, or reviewers, do not warrant that the Salinas DSP will meet the users requirements, or that the Salinas DSP will be uninterrupted or error free.

2. To the maximum extent permitted by applicable law, in no event shall the City of Salinas, its staff, consultants, contractors, advisors, or reviewers, be liable for any damages whatsoever, whether, general, incidental, special, punitive, exemplary, or consequential (including, without limitation, damages for any liabilities, losses, claims, actions or proceedings, reasonable attorneys' fees, loss of business profits, business interruption, loss of business information or other pecuniary loss) arising out of the use or inability to use the Salinas DSP.

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Section 2: Low Impact Development (LID)

2.0 What is LID?

Low Impact Development (LID) represents the storm drainage component of sustainable development. It is an innovative storm water management approach with the basic principle that is modeled after nature: manage runoff from rainfall and urban use of water at the source using uniformly distributed decentralized small scale controls, also known as integrated management practices (IMPs). IMPs are small on-lot treatment control BMPs that are integrated into the site layout, landscaping and drainage design of urban development. LID was pioneered in Prince Georges County, Maryland in the 1980's and has been applied successfully across the country and in Europe and Australia. Village Homes in Davis is one of the older examples of a residential LID design in California. The primary goal of LID is to mimic a site's pre-development hydrology by using design practices and techniques that effectively capture, filter, detain, infiltrate, and evaporate runoff close to its source. Pre-development hydrology is defined as the rate, volume and quality of runoff that would have occurred from the land surface prior to any land disturbing human activities such as agriculture or urban development. LID practices that mimic a site's predevelopment hydrology can be accomplished by implementing the following basic principles:

1. Protect natural drainageways, areas of native vegetation and high value open space, and direct runoff to soils that support infiltration;

2. Reduce the amount of compacted soil and continuously connected hard surfaces in site designs;

3. Create site design features that direct runoff to vegetated areas with engineered soils; and,

4. Educate staff, designers, and landowners about the function of LID practices and the need to maintain the viability of these practices so that they continue to function as designed.

This order mirrors the order of events that a developer/designer would undergo to apply LID and the actions that municipal and regulatory agency staff must apply to ensure the successful long term performance of LID practices.

Protecting natural drainage features and incorporating them into the site design is highly desirable in LID designs. Since natural drainage features such as swales and drainage coursers often have developed soil structures that formed over long periods of time, they can be utilized in the design of LID practices such as vegetated swales and often function much more efficiently than vegetated swales installed on imported fill materials. Conventional development techniques often remove native vegetation, reduce open space and fill natural drainage features; therefore LID strives to preserve particularly high value open space areas such as wetlands, natural riparian corridors and soils with good groundwater recharge potential. LID also strives to minimize the amount of land disturbance to only those areas necessary for construction of structures (often referred to as site fingerprinting).

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Figure 2-1 presents a comparison between the way urban runoff is typically managed in a conventional residential development and an LID landscaping approach. In the conventional development model, impervious surfaces (roofs, driveways, sidewalks, and compacted soils), and elevated (convex) landscaped areas that drain to impervious surfaces, increase runoff and pollutant discharges to the storm drain system. This approach typically results in an inefficient use of water resources and a system that drains water and other resources (e.g. topsoil and fertilizers) away and into local waterways. In the LID approach, runoff from impervious surfaces drains to depressed (concave) landscaped areas with amended soils and only runoff from relatively large storm events discharges to the storm drain system. With the LID landscaping approach, the rate, volume and pollutant loading of urban runoff can be reduced to pre-development levels and the biological and physical integrity of local waterways can be preserved and maintained.

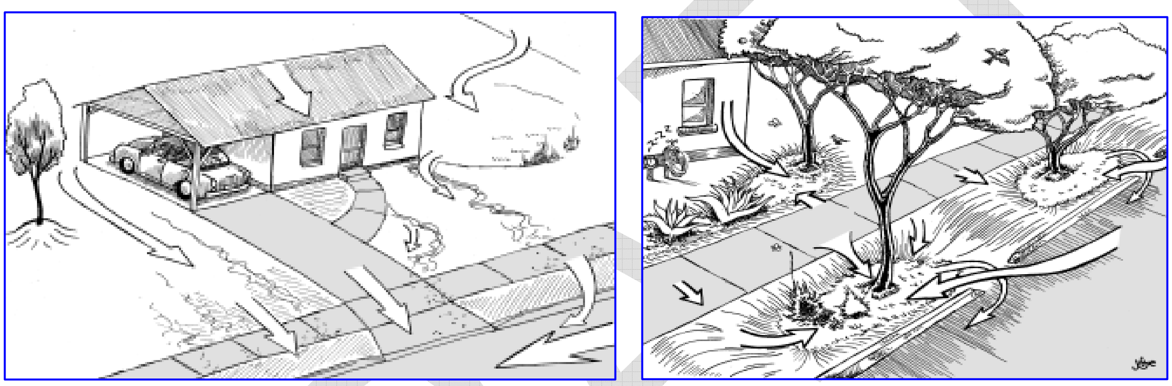

Figure 2-1: Comparison of urban runoff from a conventional development and an LID approac□. Graphics courtesy of: Brad Lancaster www.harvestingrainwater.com

Although the term LID is relatively new, the concept of incorporating design features into structures and the landscape for the purpose of capturing rainfall and runoff for beneficial purposes is very old, dating back to the beginnings of agriculture. This concept is often referred to as “Rainwater Harvesting” and includes the use of rain barrels and cisterns to capture, store and reuse roof runoff; and the creation of berms and depressed areas to divert and capture runoff to reduce the need for supplemental irrigation and improve plant health and crop yields. Several Cities in the arid southwest U.S. are rediscovering and encouraging the use rainwater harvesting techniques as a method to conserve water. Cities such as Tucson, AZ and Albuquerque, NM have an extensive amount of information available online about harvesting rainwater for landscape use.

As noted previously, conventional development and storm drainage system designs typically increase the rate, volume and pollutant loading of urban runoff, which often results in negative environmental impacts to local surface water resources. This occurs because man made impervious surfaces such as roofs, driveways, sidewalks, and compacted soils are often directly connected to each other. Runoff from directly connected impervious surfaces often drains to impervious curb and gutter systems, which then drain to storm drain inlets and a network of impervious underground pipes that discharge directly local waterways untreated. Conventional storm drain systems are designed as storm water disposal systems which efficiently drain urbanized areas and rapidly transport storm water to receiving waters. However, they also increase peak flow rates and volumes, rapidly transport pollutants, and cause downstream erosion and stream habitat degradation.

Figure 2-2 provides an example of the response of stream flow to urbanization and conventional storm drain system design within a hypothetical watershed. A watershed is defined as all the land area that contributes runoff to a particular point along a waterway. Figure 2-2 is a hydrograph, which is a graph of runoff flow rate plotted as a function of time. As can be seen on the hydrograph, runoff from conventional development typically increases the peak flow rates of urban area streams, which increases erosion. The volume of runoff, which is represented by the area under the curve, also increases and is typically not mitigated by conventional flood control structures such as detention basins. Development also leads to a reduction in natural land surfaces that previously infiltrated a portion of the annual rainfall into pervious soils. This water recharged groundwater and slowly discharged to streams and rivers. The result is that streams in urban areas with conventional development tend to dry up between storm events, but experience higher flows during storm events, further increasing erosion, changes to stream channel morphology, and loss of stream habitat. Figure 2-2 also demonstrates the typical decline in stream base flows that often occurs in response to urbanization and decreased recharge. Although the model for conventional development and storm drain system design has been in place in the U.S. for at least the last 50 years, the U.S. EPA, the SWRCB and the RWQCB are now requiring a different model to mitigate the effects of urbanization and increased impervious surfaces.

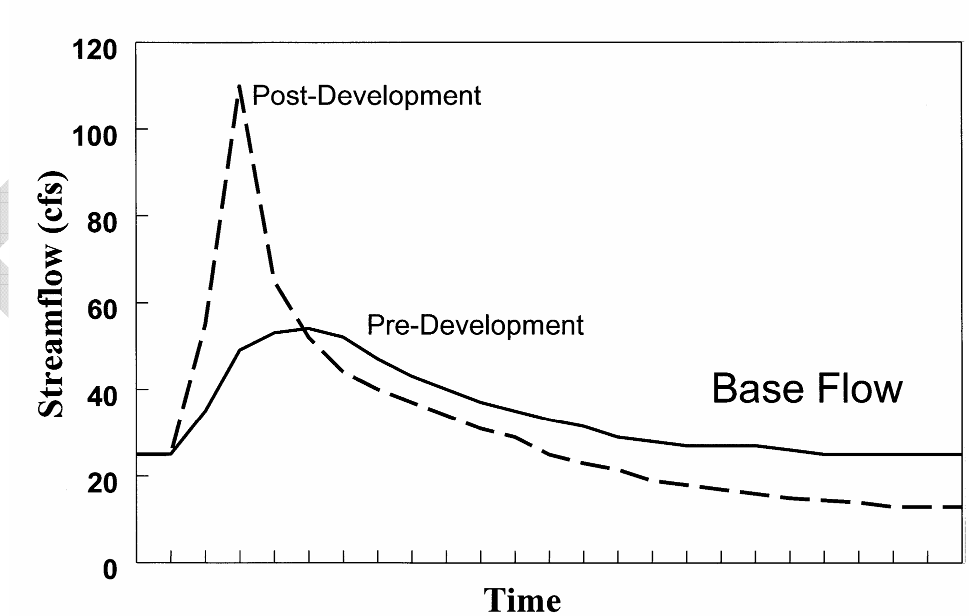

Figure 2-2: Streamflow response to conventional urbanization within a hypothetical watershed. (Source: The Center for Watershed Protection)

LID practices are based on the premise that storm water management should not be seen as merely storm water disposal. Instead of conveying the majority of runoff into underground pipes and managing and treating storm water in large, costly end-of-pipe facilities located at the bottom of drainage areas, LID addresses urban runoff through small, cost-effective landscape features located at the lot level. Although not technically considered LID, redundant semi-regional or regional facilities such as relatively large LID practices and/or the structural treatment control BMPs presented in Section 5 can also be incorporated into site designs to provide additional storm water management benefits. These facilities can provide additional treatment (e.g. a treatment train) and offset lot level practices that may not be maintained or are modified by private landowners, such as an on-lot bioretention system or vegetated swale that has been filled in by a homeowner. Redundant semi-regional or regional facilities can also be designed to function as flood control facilities. Examples of semi-regional or regional facilities include, but are not limited to, a bioretention basin for a residential neighborhood block located in the City ROW or subsurface storm water wetland cells in a flood control detention basin. Maintenance of semi-regional and regional facilities can often be more effectively controlled and secured by municipalities. In the City of Salinas, semi-regional or regional facilities located on private property will be maintained by Maintenance Assessment Districts supervised by the City.

Almost all components of the urban environment have the potential to serve as LID practices. This includes the rooftops, streetscapes, parking lots, driveways, sidewalks, medians and the open spaces of residential, commercial, industrial, civic, and municipal land uses. Anywhere landscaping can be applied also presents an opportunity for implementation of LID practices. LID is a versatile approach that can be applied equally well to new development, urban retrofits, redevelopment, and revitalization projects. Local hydrologic and geotechnical conditions, land uses and regulatory requirements must be considered in the design of LID practices.

LID is one of several new urban planning techniques. It differs from other techniques such as “Smart Growth” and “Sustainable Development” in that LID is primarily focused on alternative storm drainage techniques. Smart Growth is a term that describes the efforts of communities across the country to manage and direct growth in a way that minimizes damage to the environment and builds livable and economically sustainable towns and cities. Livability suggests, among other things, that the quality of our built environment and how well we preserve the adjacent natural environment directly affects our quality of life. Smart Growth calls for the investment of time, attention, and resources in central cities and older suburbs to restore community and vitality. It advocates patterns for newly developing areas that promote both a balanced mix of land uses and a transportation system that accommodates pedestrians, bicycles, transit and automobiles.

Sustainable Development is a term that grew out of the conservation/environmental movement of the 1970's. While the conservation/environmental movement asked questions about preserving the Earth's resources, Sustainable Development includes questions about how human decisions affect the Earth's environment. A sustainable community preserves and enhances the quality of life of residents both within and between communities, while minimizing local impacts on the natural environment. By recognizing the interdependent relationships between the natural, social, and economic parameters of a community, Sustainable Development creates conditions that strengthen the health of all. Dependent on partnerships between governments, researchers, businesses, and community members, Sustainable

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Development involves an inclusive and expansive decision-making process that considers long-term economic, ecological, and social prosperity.

LID addresses the drainage component of new development and redevelopment projects by implementing practices that mitigate the increased volume, rate, and pollutant loading of urban runoff. LID practices mimic natural hydrologic functions by filtering urban runoff through vegetation, soils and organic matter, allowing evapotranspiration by vegetation, biodegradation of pollutants by soil bacteria, infiltration and groundwater recharge. LID practices that mimic natural hydrologic functions include green roofs, vegetated swales, bioretention basins and permeable pavements. With the exception of green roofs, these LID practices can indirectly infiltrate urban runoff into underlying soils and eventually reach groundwater. Protection of groundwater quality is of utmost importance when designing storm water infiltration systems. However, the potential to contaminate groundwater by infiltrating urban runoff in properly designed and constructed treatment control BMPs with proper pretreatment is low[1]. In addition, surface soils are typically very effective at urban runoff pollutant removal and retention because a multitude of natural processes occur, including physical filtering, ion exchange, adsorption, biological processing, conversion, and uptake. In addition to providing water quality benefits and increasing groundwater recharge, LID practices can also reduce flooding potential and assist with water conservation. The RWQCB supports the use of LID practices because they meet the “maximum extent practicable” (MEP) definition for management of storm water quality and have been proven to be effective, feasible and economically practicable in other communities.

The way we design and build urban developments has a direct effect on the hydrology and water quality of a watershed and its natural water systems. The RWQCB supports the use of LID practices because they have been proven to be effective at reducing the rate, volume and pollutant loading of urban runoff in other communities and are economically feasible. LID practices also meet the RWQCB’s definition of MEP, discussed in Section 2.5 below.

Community participation in the planning and construction of LID practices, particularly at redevelopment projects, can greatly add to the long-term success of a project and increase public awareness of the need to effectively manage storm water quantity and quality. Public education signs and placards installed at LID project sites also provide additional benefits.

2.1 What is Not LID?

Conventional urban development and storm drainage system design is not LID because it typically increases the rate, volume and pollutant loading of urban runoff. Conventional storm drainage systems typically consist of impervious streets, parking lots, sidewalks, driveways, and roofs that are directly interconnected to drain to impervious curb and gutter systems and discharge to storm drain inlets and a network of impervious underground pipes. Conventional flood control detention basins are also not LID because they are typically designed to only reduce the peak flow rates of runoff from the relatively large storm events (e.g. the 25, 50, or

[1] Pitt et al., 1994. Potential Groundwater Contamination from Intentional and Nonintentional Stormwater Infiltration, U.S. Environmental Protection Agency’s Risk Reduction Engineering Laboratory, May 1994. EPA/600/SR-94/051.

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100-year storm event). They typically do not reduce pollutants in urban runoff, and unless sited on permeable soils that have not been compacted, conventional flood control detention basins typically do not allow significant infiltration and groundwater recharge (therefore they typically do not significantly reduce the volume of runoff from developed areas). In addition, conventional landscaping that consists of mounded areas that drain onto impervious surfaces is not LID. To be considered LID, landscaping must be depressed and below the grade of adjacent impervious surfaces. LID landscaping must also be designed with amended or engineered soils that provide sufficient infiltration and pollutant removal characteristics.

Some public domain, and most manufactured (proprietary), structural treatment control BMPs (presented in Section 5) are also typically not considered LID practices because most do not meet the MEP definition. When these devices are constructed of concrete enclosures, such that they do not allow infiltration through soils and/or water uptake by soils and plants, they typically do not significantly reduce the volume of runoff. In addition, devices such as underground treatment vaults and hydrodynamic or vortex separators are typically only effective at removing relatively coarse sediment, trash, debris and some oil and grease from urban runoff. They typically do not remove fine sediment, suspended sediment or dissolved pollutants, which are the primary pollutants of concern in the Salinas area and in many other areas of the nation. A number of manufactured structural treatment control BMPs also require relatively frequent maintenance and/or specialized equipment. Because they are typically underground, they can easily become "out of sight and out of mind" and are easily forgotten (i.e. not maintained). They can hold standing water permanently and can be susceptible to mosquito breeding. Therefore, they do not meet the MEP standard when used alone. However, public domain and manufactured structural treatment control BMPs can be used for pretreatment and removal of coarse sediment, trash and debris prior to further treatment by a downstream LID practice, such as a bioretention basin.

Managing and treating urban runoff with a conventional storm drainage system and costly end-of-pipe structural treatment control BMPs located at the bottom of a relatively large drainage area in also not LID. As noted above, LID addresses urban runoff through small, cost-effective landscape features located at the lot level. However, it should be noted that the science and technology of storm water treatment control BMPs in new and evolving. Innovative public domain and manufactured structural treatment control BMPs are constantly being developed to meet NPDES permit requirements. Therefore the City of Salinas should review and consider approval of new structural treatment control BMPs <u>if</u> they meet the MEP standard discussed in Section 2.5 below.

2.2 LID Site Planning Principles

As noted previously, LID storm water management techniques can restore and maintain pre-development hydrology and water quality in new development and redevelopment projects to predevelopment levels. As shown on Figure 2-3, when implemented in the planning phase of new and redevelopment projects, LID can have the greatest relative impact on reducing the rate, volume and pollutant loading of urban runoff. This is particularly true in relatively large development projects.

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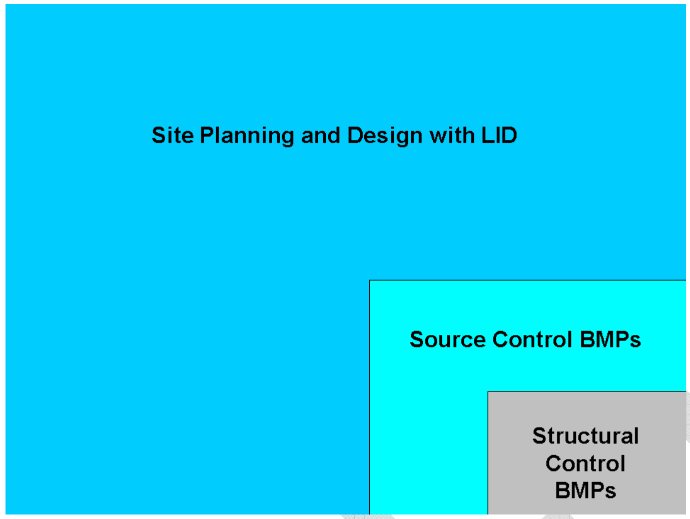

Figure 2-3: The relative effectiveness of methods to reduce the rate, volume and pollutant loading of urban runoff. (Source: Kennedy/Jenks Consultants).

LID discourages mass grading and leaving large disturbed areas unprotected for extended periods of time. This practice is also not allowed under the State Water Resources Control Board (SWRCB) General Permit for Construction Activity (Water Quality Order 99-08-DWQ) which states that "the most efficient way to address erosion control is to preserve existing vegetation where feasible, to limit disturbance, and to stabilize and revegetate disturbed areas as soon as possible after grading or construction. Particular attention must be paid to large mass-graded sites where the potential for soil exposure to the erosive effects of rainfall and wind is great."

2.3 Integrating New Urbanism and LID

As noted in the City of Salinas General Plan (2002), development in Future Growth Area will be based on the principles of New Urbanism. Therefore, it will be important to understand how LID can be incorporated into the new developments planned for this area. New Urbanism is an urban design movement which has risen to prominence since it's beginnings in the early 1980s. It aims to reform all aspects of real estate development and urban planning, including everything from urban retrofits, to suburban infill. The movement is particularly associated with the USA, with its "rediscovery" of urban patterns, which have had greater continuity in Europe. The New Urbanism movement incorporates the following planning principles:

- Walkability
- Connectivity
- Mixed-Use & Diversity
- Mixed Housing
- Quality Architecture & Urban Design

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- Traditional Neighborhood Structure
- Increased Density
- Smart Transportation
- Sustainability
- Quality of Life

As the movement has been embraced by designers, architects, planners and the associated industries, new innovations have followed. This allows the guiding principles to be increasingly applied to projects at the full range of scales, from a single building to an entire community.

As a storm water planning approach, LID represents a narrower set of planning principles. However, the goals of LID are compatible with New Urbanism, especially with the sustainability and quality of life planning principles. Though New Urbanist developments are dense, they do not preclude the use IMPs, which are the small scale decentralized storm water management techniques of LID. Design innovation and thoughtful planning can integrate LID storm water management techniques into small spaces with IMPs such as infiltration planters, tree box filters, vegetated swales, and green roofs. Parks and shared green spaces at housing complexes can be planned to function as planted infiltration areas. Disconnected and porous pavements can also be incorporated into most developments. Designers, engineers, and planners need to thoughtfully integrate LID techniques into compact New Urbanist developments. Policy, research funding, and the market will need to support these efforts.

2.4 LID and □reen Building Credits

The Leadership in Energy and Environmental Design (LEED) Green Building Rating System offers a number of credits for LID practices. These include credits for erosion control and site selection, and site designs that protect or restore habitat, maximize open space, control the quantity and quality of storm water, and utilize roofs that reduce the heat island effect (e.g. green roofs). The LEED system also provides credits for water efficient landscaping and water use reduction. Because vegetated LID practices such as bioretention systems and vegetated swales harvest rainwater and can be designed with native low water use plants, they may also apply for green building credits. In addition to sustainable site design and water efficiency, the LEED Green Building Rating System also applies credits for projects that improve energy efficiency and air quality, utilize recycled and locally manufactured materials, reuse materials and reduce construction waste. Additional information about LEED standards can be obtained from the U.S. Green Building Council (www.usgbc.org)

Significant benefits can be realized by projects that obtain LEED certification. In addition, new legislative measures that provide significant economic benefits are being passed throughout the nation to support the implementation of green buildings. For example, in 2006, Nevada Assembly Bill 3 (AB3) was passed and now mandates LEED green building standards to be applied to all new state public buildings. The bill also provides significant tax abatements for new and existing commercial buildings that meet the same LEED standards of up to 50% savings in property taxes for 10 years. These tax abatements provide significant incentives to

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the current and future owners of commercial buildings to build or retrofit them to LEED standards. California will likely follow Nevada's lead in developing similar incentives.

2.5 BMPs□MS4 and MEP

The Salinas NPDES Permit requires the City to implement Best Management Practices (BMPs) and reduce the discharge of pollutant loads to and from the municipal separate storm sewer system (MS4) to the "maximum extent practicable" (MEP). The following section provides a description of each of these storm water management terms.

<u>Best Management Practices (BMPs)</u>

A Best Management Practice (BMP) refers to any kind of procedure or device designed to minimize the quantity of pollutants that enter the municipal storm drain system (e.g. the MS4). Since the beginning of the NPDES storm water program in 1990, a rough taxonomy of BMPs has emerged. BMPs can be classified in three general ways; temporary construction BMPs, source control BMPs and structural treatment control BMPs. Source control BMPs can be further subdivided into operational BMPs and integrated management practices, or IMPs.

Temporary Construction BMPs are intended to control erosion and sediment transport during the construction phase of new development and redevelopment projects (e.g. tracking and mulching are typical erosion control BMPs and silt fences and fiber rolls are typical sediment controls. Temporary Construction BMPs are also intended to control and contain the discharge of chemicals and materials from construction equipment and stockpiled supplies. Once construction is complete, excess supplies and debris are removed and bare soil areas are stabilized (e.g. revegetated), these BMPs and are to be removed. Some construction BMPs can also later serve as permanent Structural Treatment Control BMPs (e.g. a sediment retention basin designed to serve as an extended detention basin after construction is complete). Additional information about Construction BMPs is presented in Section 5.1.

Source Control BMPs (also known as **source control measures** or **non-structural BMPs**) aim to stop pollutants from entering storm water at their source. All **Operational BMPs** (described below) are for source control, but source control BMPs can also be site design features that prevent rain water from contacting a potential pollutant source (e.g. a roof over a storage area). Since the objective of LID is to control and treat urban runoff as close to the source as possible, many LID design practices can be considered source control BMPs. LID practices integrated into the landscape design and distributed throughout the site are known as Integrated Management Practices, or IMPs), which are another form of source control. Additional information about post-construction Source Control BMPs is presented in Section 5.2.

Structural Treatment Control BMPs are built devices or facilities that remove pollutants that have already become suspended or dissolved in storm water. When designed by an engineer based on public design guidance manuals, they are considered **Public Domain Structural Treatment Control BMPs**. When pre-manufactured devices are purchased from a supplier they are considered **Manufactured (Proprietary) Structural Treatment Control BMPs**. A sand filter or a sedimentation basin designed to treat runoff from an urban drainage area that includes a number of impervious surfaces is considered a public domain structural treatment

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control BMP. Both IMPs and most public domain structural treatment control BMPs can be designed to also reduce the volume, rate and duration of urban runoff. Therefore, they can be designed to meet the MEP standard of the Salinas NPDES permit. They can also be designed to part of the flood control system that must be incorporated into urban development to safely convey runoff from the infrequent large storm events. However, most manufactured structural treatment control BMPs do not reduce the volume, rate and duration of urban runoff. Therefore, when used alone, they typically do not meet the MEP standard. Structural Treatment Control BMPs are discussed in detail in sections 5.3 and 5.4.

Operational BMPs are practices or procedures that prevent pollutants from entering storm water. Activities such as dumping wash water in an indoor sink rather than the gutter, sweeping outside work areas daily, and conducting routine maintenance activities to ensure structural treatment controls function as designed are considered operational BMPs.

<u>Municipal Separate Storm Sewer System (MS4)</u>

The Municipal Separate Storm Sewer System (MS4) is the conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains) owned and operated by a state, county, city, town, district, association, or other public body (created by or pursuant to state law) having jurisdiction over the disposal of sewage, industrial wastes, storm water, or other wastes, that discharges to waters of the United States. [40 CFR 122.26(b)(8)]. Therefore the MS4 within a City typically includes the public roadways, curb and gutter systems, storm drain inlets and catch basins, underground storm drain pipes, man-made channels, and detention basins.

<u>Maximum Extent Practicable</u>

Per the Salinas NPDES permit, the Maximum Extent Practicable (MEP) standard is defined as "the emphasis of pollution prevention and source control BMPs as the first lines of defense in combination with structural and treatment methods where appropriate serving as additional lines of defense. The MEP approach is an ever evolving, flexible, and advancing concept, which considers technical and economic feasibility." The Salinas NPDES permit further states that "the RWQCB will determine compliance with MEP standards based on the terms of the Permit, including Attachment 4; and SWRCB decisions or guidance, EPA regulations and guidance and applicable case law defining MEP." In addition, the December 22, 2005 RWQCB letter to the City of Salinas indicates that LID techniques implemented in new development meet the MEP definition.

MEP, as described by the SWRCB includes the following. "The federal Clean Water Act (CWA) provides that NPDES permits for Municipal Separate Storm Sewer Systems (MS4) must require municipalities to reduce pollutants in their storm water discharges to the MEP (CWA §402(p)(3)(B)). MS4 permits shall require controls to reduce the discharge of pollutants to the maximum extent practicable, including management practices, control techniques and system, design and engineering methods."

The MEP standard involves applying best management practices (BMPs) that are effective in reducing the discharge of pollutants in storm water runoff. In discussing the MEP standard, the

SWRCB has said the following: "There must be a serious attempt to comply, and practical solutions may not be lightly rejected. If, from the list of BMPs, a permittee chooses only a few of the least expensive methods, it is likely that MEP has not been met. On the other hand, if a permittee employs all applicable BMPs, except those where it can show that they are not technically feasible in the locality, or whose cost would exceed any benefit to be derived, it would have met the standard. MEP requires permittees to choose effective BMPs, and to reject applicable BMPs only where other effective BMPs will serve the same purpose, the BMPs would not be technically feasible, or the cost would be prohibitive." (Order No. WQ 2000-11, at p.20.) MEP is the result of the cumulative effect of implementing, continuously evaluating, and making corresponding changes to a variety of technically and economically feasible BMPs that ensures the most appropriate controls are implemented in the most effective manner. This process of implementing, evaluating, revising, or adding new BMPs is commonly referred to as the iterative approach. For Small MS4s, EPA has stated that pollutant reductions to the MEP will be realized by implementing BMPs through the six minimum measures described in the permit. (64 Federal Register 68753.) http://www.waterboards.c.gov/stormwtr/smallms4faq.html

2. Impervious Surfaces

Imperviousness is the characteristic of a material, which allows or prevents the effective passage of water through it (e.g. no effective infiltration). Impervious surfaces are hard surfaces that prevent or retard the entry of water into the soil mantle and causes water to run off the surface in greater quantities or at a greater rate of flow than under natural pre-developed conditions. Impervious surfaces include, but are not limited to, building rooftops, roads, streets, driveways, parking lots, rooftops, patios, sidewalks and compacted soils. Gravel pavement over sandy soils is highly permeable and is not considered an impervious surface. However gravel pavement over clay soils is considered an impervious surface. Open, uncovered retention or detention facilities are not considered impervious surfaces.

The aerial extent and direct connection of impervious surfaces should be considered the “unifying theme” for the efforts of planners, engineers, landscape architects, scientists, and local officials concerned with urban watershed protection (Schueler, 1995). As noted previously impervious surfaces in urban land development and conventional storm drain system design are often directly linked to the degradation of aquatic ecosystems. However, when imperviousness is quantified, managed, and controlled (e.g. minimized and disconnected) during land development planning and design, impacts can be significantly reduced. Imperviousness has long been understood as the key variable in urban hydrology and conventional storm drain system design. Peak runoff flow and total runoff volume from relatively small urban drainage areas can be calculated as a function of the ratio of impervious area to total area using the empirically derived Rational Method. The Rational Method correlates peak flow to the runoff coefficient “C”, where the maximum value is 1.0 and the minimum value is 0.01. Relatively high C values are assigned to impervious surfaces such as roadway pavement (e.g. C = 0.9), whereas relatively pervious surfaces such as sandy soils are typically assigned relatively low values (e.g. C = 0.05). The appropriate C values to be used with the Rational Method in the City are presented in the City of Salinas Standard Specifications, Design Standards and Standard Plans.

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Increased flows resulting from urban development tend to increase the frequency of flooding downstream. Imperviousness links urban land development to degradation of aquatic ecosystems in two principal ways. First, the combination of paved surfaces and piped runoff efficiently collects urban pollutants and transports them, in suspended or dissolved form, to surface waters. These pollutants may originate as airborne dust, be washed from the atmosphere during rains, or may be generated by automobiles and outdoor work activities.

Second, increased peak flows and runoff durations typically cause erosion of stream banks and beds, transport of fine sediments, and the degradation of aquatic habitats. Measures taken to control stream erosion, such as hardening banks with riprap or concrete, may permanently eliminate habitat. As shown on Figure 2.2, increased imperviousness often reduces infiltration and groundwater recharge, which may also reduce dry-weather stream flows (e.g. base flows). Imperviousness has two major components: rooftops and transportation corridors (including streets, highways, and parking areas). The transportation component is usually larger and is more likely to be directly connected to the storm drain system.

The effects of imperviousness can be mitigated by disconnecting impervious areas from the drainage system and by making drainage less efficient (e.g. by encouraging detention and retention of runoff in IMPs and LID practices located near the point where it is generated). Extended detention and retention basins also reduce peak flows and volumes and allow pollutants to settle out or adhere to soils before they can be transported downstream. These storm water management practices can also be sized to reduce peak flows generated by the infrequently occurring large storm events (e.g. the 25, 50, or 100-year storm event).

2. Storm Water Quality Design Storms

Engineers and hydrologists have been using statistically derived design storms to calculate the required size of storm drainage facilities that convey, detain and store urban runoff for many years. These facilities are typically based on statistics of relatively large storm events to protect public safety and prevent flooding. Because small storms occur relatively frequently throughout the course of a year, it stands to reason that these relatively frequently occurring storm events wash urban surfaces most frequently and transport the largest pollutant loads. Studies, such as the Nationwide Urban Runoff Program (NURP) study (U.S. EPA, 1983) have shown that the relatively frequent small storm events and the first 15 to 30 minutes of runoff from all storms, known as the "first flush", contain the highest concentrations of pollutants in urban runoff. Therefore, certain LID practices and structural treatment control BMPs should be designed to treat the rate and volume of urban runoff produced by the locally occurring relatively small storm events. The National Water Quality Inventory: 2000 Report to Congress identified urban runoff as one of the leading sources of water quality impairment in surface waters. Under the NPDES program, it is now a nationwide requirement to treat the rate and volume of urban runoff produced by the relatively small storm events that occur locally.

Since no two rainstorms are exactly alike and new storms provide new data, hydrologists periodically sort and analyze rain gauge records to find long-term patterns of rainfall intensity and duration. They then apply engineering calculations and other methods to estimate runoff flow rates and volumes. These methods are based on patterns of rainfall intensity and duration, the size, topography, soils, the land uses within a particular watershed, and the runoff travel

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time in its drainage areas. Different design storms apply to different purposes. Design storms for the design of conventional storm drain systems typically target the relatively large storm events. For example, large flood control channels are typically designed to convey runoff from storms with a one-in-one-hundred (1%) probability of occurring in any particular year, commonly called the 100-year storm event. Conventional flood-control detention basins are often designed to capture and reduce flows from storms that have a 4% or 10% of probability of occurring each year (a 25-year or 10-year storm, respectively). Although these conventional storm drain system designs can be effective at reducing potential flooding, they can increase downstream risks and typically fail to reduce the increased volume and pollutant loading of urban runoff from conventional development. Therefore, design techniques such as LID are necessary to offset these additional impacts of urban runoff.

Rather than specifying a design storm, NPDES storm water permit design criteria for certain LID practices (e.g. bioretention systems and vegetated swales) and structural treatment control BMPs typically target the treatment of 80 to 85% of the volume or rate of average annual runoff. This value was derived from studies such as the NURP study discussed above. To achieve treatment of 80% to 85% of the volume or rate of average annual runoff, treatment control BMPs should be sized based on a statistical analysis of local rainfall data. As with all NPDES storm water permits, the Salinas NPDES Permit requires numeric sizing criteria for both volume- and flow-based treatment control BMPs. As discussed in Section 4.5, volume-based treatment control BMPs should be designed to treat the volume produced by the 24-hour 85th percentile storm event, based on local rainfall records. Whereas flow-based treatment control BMPs should be designed to infiltrate or treat the maximum flow rate produced by a rain event equal to two times the 85th percentile hourly rainfall intensity. As noted previously, facilities designed to treat these smaller relatively frequent storms are typically considerably smaller than flood control facilities.

A statistical analysis of rainfall data was conducted for the Salinas area. Figures 2-4 and 2-5 indicate that the majority of storms in the Salinas area produce 0.50 inches or less of rainfall at a rate of 0.10 inches/hour or less. As discussed in Section 4.5, the rainfall depth associated with the 24-hour 85th percentile storm event is 0.60 inches. Whereas the rainfall intensity associated with the 24-hour 85th percentile storm is 0.11 inches/hour. Therefore, two times this value is 0.22 inches/hour. These are the values that should be used to size volume- and flow-based treatment control BMPs in the Salinas area. The Salinas numeric sizing criteria for volume- and flow-based treatment control BMPs is discussed in detail Section 4.5.

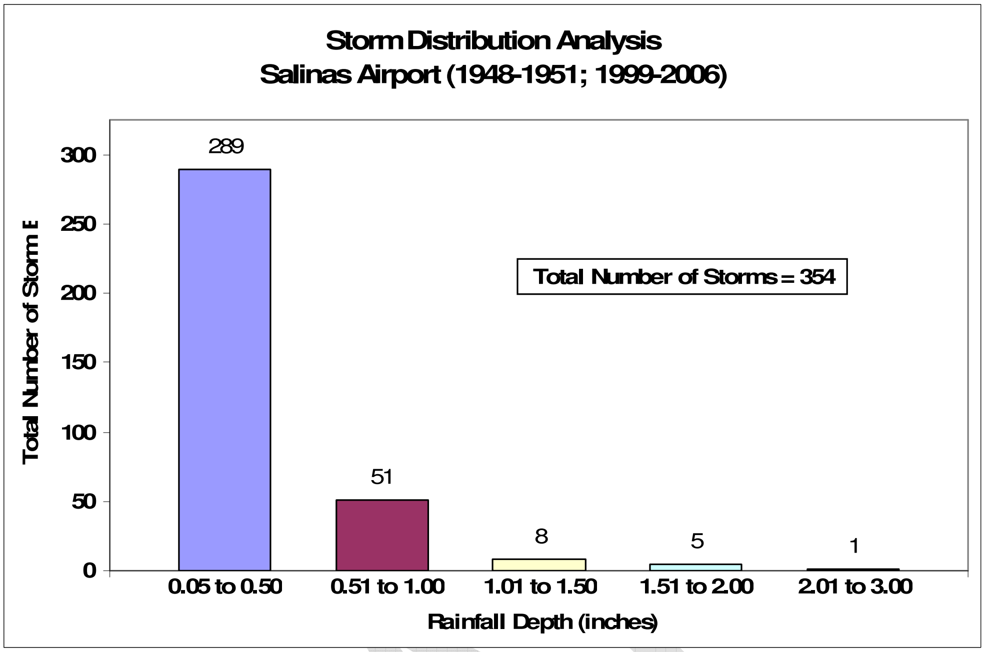

Figure 2-4: Storm distribution analysis for the Salinas area. (Source: Kennedy/Jenks Consultants)

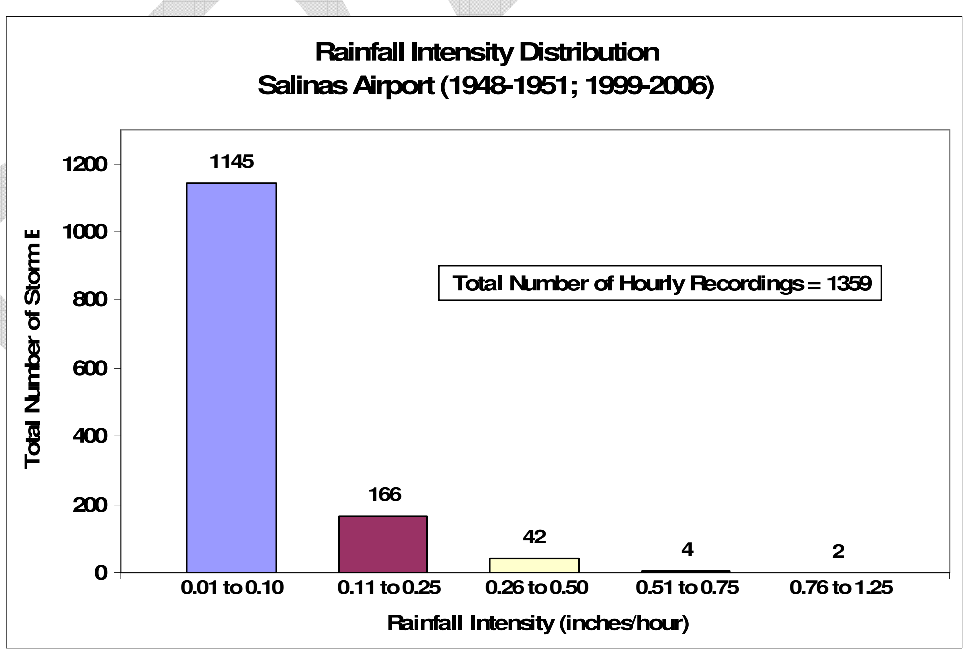

Figure 2-5: Rainfall intensity distribution analysis for the Salinas area. (Source: Kennedy/Jenks Consultants)

2.□ Infiltration and Percolation

As a storm water management/LID method, the term infiltration refers to practices that retain or detain urban runoff within permeable soils. Depending on: a) the amount of runoff, b) the design of the storm water infiltration practice and, c) the soil permeability in existing site soils, a portion of the runoff that enters the device can infiltrate into underlying soils and recharge groundwater. Infiltration is the primary mechanism in LID practices for reducing the rate, volume, and pollutant loading of urban runoff. Soil amendments are typically required to increase the permeability and pollutant removal effectiveness of existing site soils, particularly in areas with clayey soils. The following presents several important concepts with respect to the infiltration of storm water and LID.

Infiltration Rate – means the rate at which water percolates into the subsoil measured in inches per hour or minutes per inch.

Direct Storm Water Infiltration – means any structure that is designed to infiltrate storm water into the subsurface and by design, bypasses the natural groundwater protection afforded by surface or near-surface soils. Direct infiltration systems include infiltration trenches, infiltration basins, and dry wells. These devices are typically constructed of gravel and can impact groundwater quality if improperly sited (e.g. in a drainage area susceptible to spills).

Indirect Storm Water infiltration – means infiltration into subsurface soils via surface facilities that include amended soils and sand. Indirect infiltration practices include vegetated swales, bioretention systems, and porous pavements. These LID practices are expressly designed to convey or detain runoff and allow it to filter through engineered soils prior to infiltration into shallow subsurface soils, generally less than 5 ft below ground surface. Treated storm water runoff may reach groundwater indirectly, or it may be underdrained through subsurface pipes to the conventional storm drain system. These devices are highly effective at removing pollutants from storm water and typically present little threat to groundwater quality.

Soil percolation describes the transport of soil water based on the most restrictive shallow soil layer (e.g. a clayey soil layer). Infiltration or percolation testing of existing site soils is often required by municipalities when storm water infiltration BMPs are proposed to be installed because infiltration or percolation rates are necessary to properly design storm water infiltration BMPs. Infiltration testing is typically conducted using a double ring infiltrometer and infiltration rates are typically reported in units of inches/hour. Whereas percolation testing methods are simpler than infiltration testing methods and are typically established for the permitting of septic system leach fields. Percolation rates are typically reported in units in minutes/inch. As can be seen on Figure 2.6, infiltration and percolation rates are dimensionally opposite from each other; as infiltration rates reported in inches/hour go down, corresponding percolation rates reported in minutes/inch goes up (e.g. 1.0 in/hr = 60 min/in and 0.5 in/hr = 120 min/in). This concept is important to understand when interpreting infiltration or percolation testing data for the design of storm water infiltration systems.

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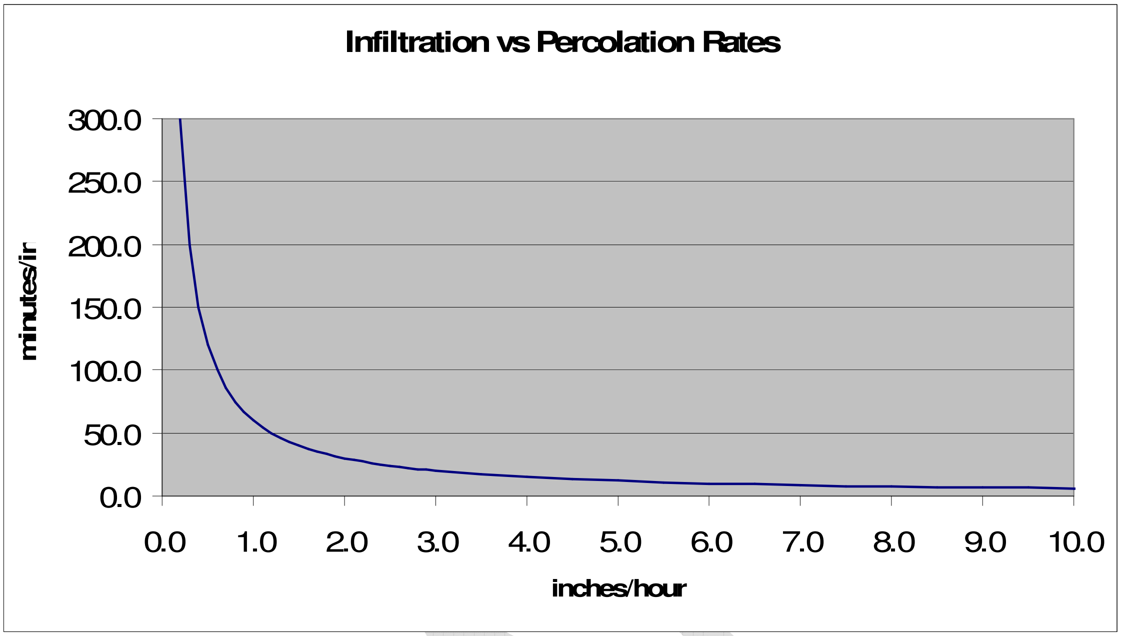

Figure 2-□: Relations□ip between infiltration rates and percolation rates.

Additional information about infiltration of storm water in urban areas and the measures that must be taken to protect groundwater quality and structures such as building foundations, as well as a number of other parameters, is discussed in detail in Section 4.2.

2.□ Amended and Engineered Soils

Soil amendments are materials added to improve the physical properties of soils. They are typically mixed into soils to provide a better environment for plant roots. Engineered soils for LID practices are specific mixes of soil materials and amendments developed for the purpose of infiltrating and treating urban runoff while producing a favorable environment for plants.

When properly selected and applied, organic soil amendments increase soil organic matter content and improve soil aeration, water infiltration, and both water and nutrient holding capacity. Many organic amendments contain plant nutrients and act as organic fertilizers. Organic matter is also an important energy source for bacteria, fungi and earthworms that live in the soil. Soil bacteria and fungi degrade a number of the pollutants commonly found in urban runoff. Therefore establishment of soil bacteria and fungi are critical components of engineered soils for LID practices such as bioretention systems.

Soil amendments can be organic and inorganic. Organic amendments are derived from plant matter and animal waste. Inorganic amendments are either mined or man-made. Organic amendments include sphagnum peat moss, grass clippings, straw, compost, manure, biosolids, wood chips, sawdust and wood ash. Inorganic amendments include vermiculite, perlite, pea gravel and sand. Mulches are not considered soil amendments because they are placed on the soil surface to reduce erosion and improve soil moisture (e.g. they are not mixed into the soil).

Not all of the amendments noted above are recommended for use in vegetated LID practices. They are merely provided as examples. For example, wood products such as wood chips and sawdust are not desirable because they can tie up nitrogen in the soil and cause nitrogen deficiency in plants. Wood ash is typically high in both pH and salts and can magnify common soil problems. Therefore wood ash should not be used as a soil amendment in vegetated LID practices. Sand should also not be added to clay soils because it can create a soil structure similar to concrete.

Biosolids are byproducts of sewage treatment facilities. They may be found alone or composted with leaves and/or other organic materials. The primary concern about biosolids is that they may contain heavy metals, pathogens, and salts. Therefore biosolids should not be used as a soil amendment in vegetated LID practices. Manure can also contain elevated levels of ammonia and pathogens and should not be used. Manure must be composted for at least two heating cycles at 130 to 140 degrees F to kill any pathogens. Most home composting systems do not sustain temperatures at this level. In addition, composted manure typically contains elevated levels of phosphorus, potassium and salts. Therefore composts containing manure are also not recommended for vegetated LID practices.

Care should always be applied to the selection of the soil amendments in vegetated LID practices such as bioretention systems because if they contain relatively high levels of nitrogen, phosphorous, a relatively high P-index, or soluble salts, these components may leached out of the soil mix and into the effluent (draining to groundwater or discharging to a storm drain pipe or a drainage channel if an underdrain system is included in the design). Vegetated LID practices differ from ordinary conventional landscaping because they are designed to have urban runoff flow into them from adjacent developed impervious surfaces. Urban runoff therefore concentrates in vegetated LID practices by design and there is a much higher potential to leach nutrients out of bioretention systems if they are not designed correctly. Sphagnum peat moss and compost made from purely plant sources are low in salts and are good choices for amending soils in vegetated LID practices. An analysis of the soil mix is always recommended.

As noted above, engineered soils for LID practices represent specific mixes of soil materials and amendments. They are developed exclusively for the purpose of infiltrating and treating urban runoff while producing a favorable environment for plant roots. As discussed in detail in Section 4.4, engineered soils for bioretention systems should have a sandy loam or loamy sand texture and consist of 50-60% clean sand; 5-20% certified compost or peat moss; and 20-30% topsoil with a maximum clay content of <5%.

Soil amendments are defined by the SWRCB as any material that is added to the soil to change its chemical properties, engineering properties, or erosion resistance. Certain soil amendments can be mobilized by storm water and become pollutants. Soil amendments likely to fall in this category include lime, cementitious binders, chlorides, emulsions, polymers, soil stabilizers, and tackifiers applied as a stand-alone treatment (i.e., without mulch). In contrast, plant fibers (such as straw or hay), wood and recycled paper fibers (such as mulches and matrices), bark or wood chips, green waste or composted organic materials, and biodegradable or synthetic blanket

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fibers are soil amendments that are likely to be visible in storm water runoff. All of the soil amendments noted above are much more likely to be mobilized by storm water and become pollutant when applied to conventional mounded (convex) landscaping. Whereas they are much more likely to be trapped and treated by depressed LID (concave) landscaping.

2.10 References and Additional Resources

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California Stormwater Quality Association (CASQA), 2003. California Stormwater Best Management Practices Handbook, New Development and Redevelopment, January 2003 (Updated September 2004) www.cabmphandbooks.com/

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Stormwater Quality Design Manual for the Sacramento and South Placer Regions, 2007.

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U.S. EPA, 2005. National Management Measures to Control Nonpoint Source Pollution from Urban Areas

U.S. EPA, 2006. Handbook for Developing Watershed Plans to Restore and Protect Our Waters www.epa.gov/nps/watershed_handbook

Twin Cities Metropolitan Council: Urban Small Sites Best Management Practice Manual

Urban Drainage and Flood Control District (UDFCD), 1999. Urban Storm Drainage Criteria Manual, Volume 3 – Best Management Practices (Revised 2005). Denver, Colorado.

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Section 3: LID Designs and Practices

3.0 LID Planning Techniques

As discussed in detail in the previous section, conventional development and storm drain system designs typically increase runoff, contribute pollutants to surface waters, and reduce groundwater recharge. Therefore LID designs and practices must be implemented to offset these negative impacts. All successful designs and practices require proper planning and engineering. Therefore LID designs and practices must be carefully planned and adhere to a set of basic planning principles. It should be understood that LID planning principles require different site and facility design considerations than conventional development and storm drain system design. To be successful, LID planning principles for the protection of local water resources should consist of the following strategies:

1. Reducing or maintaining post-project runoff to pre-development conditions;
2. Controlling sources of pollutants; and
3. Treating polluted storm water runoff before discharging it to the storm drain system or to receiving waters (if still needed after implementing 1 and 2).

Planning elements 1 and 2 emphasize reducing or eliminating pollutants in storm water runoff at their source by capturing and reducing the volume and rate of runoff and the exposure of pollutants to rainfall and runoff from other sources. This can be accomplished by implementing LID practices in site designs and source control BMPs. Planning element 3 considers the implementation of structural treatment control BMPs, which are engineered systems typically consisting of piping, filter media, and concrete structures that primarily use physical methods to reduce pollutants in storm water. Source control and structural treatment control BMPs are discussed in detail in Section 5. If LID planning principles 1 and 2 are incorporated into the design of many new development and redevelopment projects, particularly land uses such as residential developments, LID practices and source control BMPs alone can effectively reduce runoff and control sources of pollutants. However, some industrial and commercial land uses may require a combination of LID practices, source and structural treatment control BMPs to meet local water quality standards and the MEP definition discussed in Section 2.4.

Every potential development site possesses a unique combination topographic, physical, hydrologic, soil, and vegetative features. Some sites are more suitable than others for certain types of BMPs. However the integration and incorporation of LID landscaping techniques can be widely applied. Landscaping strategies that drain and filter storm water are the one of the most effective methods of minimizing surface and groundwater impacts from storm water runoff. Green roofs and routing roof runoff through LID landscaping techniques provide additional storm water management benefits. Reducing the amount of dry-weather flows through the use of efficient irrigation systems and discouraging outdoor washing activities also helps to reduce runoff and the transport of pollutants to receiving waters. LID landscaping techniques, roof runoff controls and efficient irrigation techniques have the additional benefit of assisting with water conservation efforts while minimizing public health vector nuisances. Finally, the labeling of storm drain inlets with messages such as “No Dumping – Flows to Creek” provides a highly visible public education message. It helps to educate the general public that the storm water

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runoff from streets and parking lots is conveyed through the storm drain system and does not receive treatment prior to discharge to local streams, rivers and lakes.

The following sections discuss the LID planning principles of protecting Preserving Existing Vegetation, Filtering Waterways, Creating and Preserving Open Space, and Tree Planting and Parkway Designs. Additional information about planning principles and site design techniques that replicate pre-existing hydrologic site conditions can be obtained at the Low Impact Development (LID) Center http://www.lowimpactdevelopment.org/

3.0.0 Preserving Existing Vegetation

Measures to preserve existing vegetation, both native and established landscaping, should be implemented wherever possible to protect and preserve existing high value plants and trees in areas that will be exposed to land-disturbing activities. This LID planning principle should be used on all construction sites and is particularly applicable where projects areas are located in floodplains, near streams, wetlands, and steep slopes.

Design Planning Considerations

- Assess proposed development areas to determine areas of existing vegetation that should be preserved. Appropriate assessment professionals include botanists, biologists, arborists and landscape architects.
- Design sites to fit into existing contours and preserve existing vegetation to the extent feasible or required by local ordinances.
- Consider plant and tree health, age, species, space needed, aesthetic values, and habitat benefits.
- Design new landscaping to provide consistency with existing vegetation to be preserved on site or in the surrounding area.
- Follow existing contours and avoiding stands of trees and other high value vegetation when locating temporary roadways.

Construction Planning Considerations

- Clearly mark areas to be preserved on maps and plans with Preserve Existing Vegetation (PEV) lines.
- Install temporary fencing to protect existing vegetation before beginning clearing or other soil-disturbing activities.
- When protecting trees, extend the limits of fencing to at least the tree drip-line (the horizontal extent of the tree branches).
- Do not place equipment, construction materials, topsoil, or fill dirt within the limit of tree drip-lines or other preserved areas.
- Do not cut tree roots within the tree drip line and curving trenches around trees to avoid large root concentrations.

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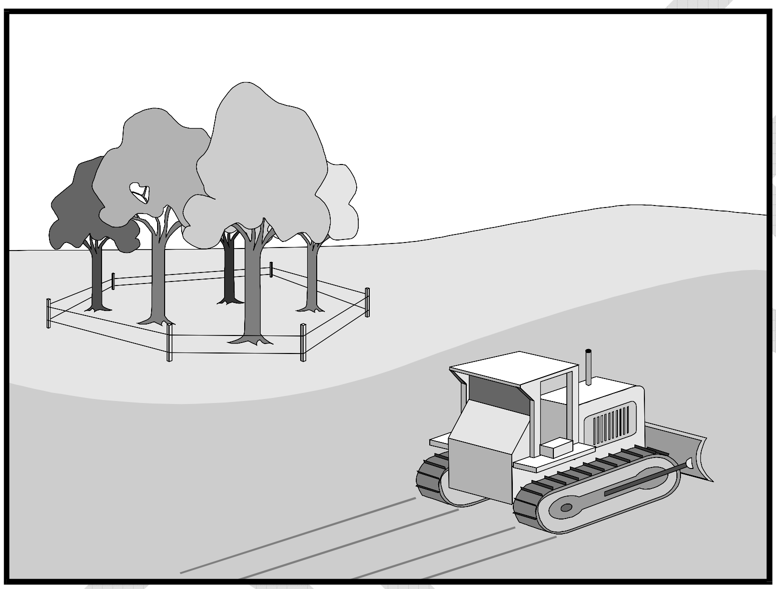
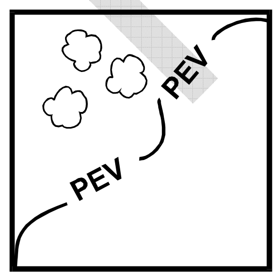
- Repair or replace damaged vegetation immediately. If tree roots are cut, the ends should be smoothly cut. Exposed tree roots should be covered with soil or wet burlap as soon as possible.
- Excavation within the drip line should be accomplished by hand, and roots 1/2" in diameter and larger should be preserved.
- Any pruning of the branches or roots should be completed by, or under the supervision of, an arborist.
- Maintaining existing irrigation systems and supply additional supplemental irrigation when necessary to protect the health of existing plants and trees.
- Fertilizing broadleaf trees that have been stressed or damaged to aid the recovery and consulting an arborist to determine if and what kind of fertilizer is needed.





MAP SYMBOL

Figure 3-1: Example BMPs for preserving existing vegetation at construction sites. Graphics used with permission of Caltrans)

3.0.1 Filtering Waterways

Waterways include wetlands, streams, rivers, ponds and lakes. Areas adjacent to streams and rivers that support a wide variety of plant and animal species are known as “riparian areas”. Riparian areas are dependent on the hydrology of streams and rivers and typically have shallow groundwater. Codes and ordinances must be developed and enforced to protect waterways and prevent or significantly limit development within specified limits or setbacks.

The City of Salinas Grading Ordinance protects riparian corridors and wetlands through minimum 100-ft setbacks. Developments must retain creeks and wetlands in their natural channels. It discourages the use of culverts or underground pipes and requires a riparian/wetland habitat mitigation and management plan if impacts are incurred to such waterways during development.

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3.0.2 Creating and Preserving Open Space

Protecting natural drainageways (e.g. dry channels that convey water during storm events), areas of native vegetation, and high value open space is one of the primary principles of LID. Open space filters and greenbelt areas should be established to help define boundaries between development areas and neighborhoods, to prevent urban sprawl, and to protect sensitive habitats. Codes and ordinances should be developed and enforced that require the establishment of open space buffers and greenbelt areas.

The City of Salinas Zoning Code, Municipal Code, and General Plan contain language that supports the creation and preservation of open space in development areas.

Cluster and open space development are LID site design strategies that concentrate development to specific areas of a site, leaving portions of the development in open space. These designs include strategies such as smaller lot sizes, alternative street layouts to reduce road networks and area of impervious pavements, alternative driveway designs, and alternative sidewalk designs (discussed in the following sections). Often, a community's zoning regulations may need to be revised to meet these goals. When choosing the development envelope for a site, features such as riparian areas, woodland conservation areas, steep slopes, and highly erosive or permeable soils must be protected.

Figure 3-2: Comparison of a LID site plan to a conventional site plan on the same site. (Images courtesy of Puget Sound Action Team)

Conventional Site Plan | **LID Site Plan Utilizing Open Space and Cluster Development**

An example of a development that utilized cluster and open space development is the Pembroke development in northern Fredrick County, Maryland. The development utilized half-acre residential plots and LID site design strategies to address storm water management within the subdivision. By utilizing LID strategies and preserving two-and-a-half acres of undisturbed open space and wetlands to aid in storm water runoff control, two storm water ponds were eliminated from the site plan, saving the developer $200,000 in infrastructure costs. LID site foot-printing techniques allowed for preservation of 50 percent of the site in undisturbed wooded condition. Two additional lots were also gained from LID site design increasing the site yield from 68 to 70 on the 43-acre site. Replacing curbs and gutters with vegetated swales and reducing road width from 36 to 30 feet reduced impervious cover. Paving costs were lowered by 17 percent with a $60,000 saving in utilizing swales.[2]

3.0.3 Tree Planting and Par□way Designs

Trees can be used in urban settings as part of a storm water management plan to reduce runoff and pollutant loads from development projects. Trees can be placed on residential lots, in landscape corridors, parking lots, and along street frontages. Urban areas with large numbers of trees exhibit hydrology more similar to pre-development conditions than urban areas with little to no tree canopy. This occurs because trees intercept rainfall and can retain a significant volume of the captured water on leaves and branches, allowing for evaporation and providing runoff reduction benefits. For example, a large oak tree can intercept and retain more than 500 to 1,000 gallons of rainfall in a given year[3]. Evergreen trees have the greatest potential to provide storm water management benefits because they retain their leaves throughout the rainy season. Generally, the larger the tree and the smaller the leaves, the more rain is intercepted. In addition, tree roots help to support infiltration into urban soils by providing pathways through relatively tight soils (clayey and silty soils)

The shade provided by trees also keeps the ground and impervious surfaces under trees cooler. This reduces the amount of heat gained in runoff that flows over the ground and impervious surfaces located under the trees. This attenuation of heat in storm water helps control increases in stream temperatures. On slopes, tree roots also hold soil in place and prevent erosion.

Planning Considerations

- Check with the local permitting agency about requirements for trees located in public utility easements.
- Trees should be located appropriate distances from infrastructure and structures that could be damaged by roots and branches. These include, but are not limited to, overhead utilities and lighting, underground utilities, signage, septic systems, curb/gutter and sidewalks, paved surfaces, building foundations and existing trees.
- Select tree species based on the soils found on the site, available water, and aesthetics.
- Consult a landscape architect or arborist to ensure suitability of species for site conditions and design intent.
- Do not plant trees too close together and avoid plant monocultures of same family, genus and/or cultivar.

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[2] Natural Resources Defense Council (NRDC). 2001. Stormwater Strategies: Community Responses to Runoff Pollution http://www.nrdc.org/water/pollution/storm/chap12.asp

[3] Cappiella, K. 2004. *Urban Watershed Forestry Manual* (draft). Prepared for USDA Northeastern Area State and Private Forestry. Center for Watershed Protection, Ellicott City, MD

- New landscaping under existing trees should be carefully planned to avoid any grade changes and any excess moisture in trunk area, depending on tree species. Existing plants which are compatible as to irrigation requirements and which complement the trees as to color, texture and form should be saved.
- Grade changes greater than six inches within the drip-line of existing trees should be avoided.
- Avoid soil compaction within the tree drip-line (horizontal extent of the tree branches).
- Trees should be installed and irrigated in accordance with local permitting agency Landscaping Standards.
- When installing lawn around trees, install the grass no closer than 24 inches from the trunk.
- Consider using mulch around the base of the tree as a substitute to fertilizer. Do not place mulch within six inches of the trunk of the tree.
- Mulch trees with hardwood chips (not redwood or cedar).
- Minimize the use of chemicals to only what is necessary to maintain the health of the tree.

If not already in place, the City of Salinas should consider establishing a list of approved tree species for various land uses and settings, particularly for street trees and parkway designs. It could be included in the Salinas DSP here. Joni L. Janecki & Associates initiated discussions with City staff about this subject in September, 2006. In addition, runoff reduction credits for tree species that effectively intercept rainfall should be considered by both the City and the Regional Board. Examples of runoff reduction credits for interceptor trees are included in the Stormwater Quality Design Manual for the Sacramento and South Placer Regions (2007) and the City of Portland, OR, Stormwater Management Manual (2005) .

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3.1 Minimizing and Disconnecting Impervious Surfaces

3.1.0 Rooftop Disconnection

Runoff from the roofs of buildings and homes contributes to the volume of storm water runoff as well as acting as a source of pollutants, particularly at industrial and commercial facilities. During a storm event, runoff from rooftops is generally collected in gutters and poured into downspouts, or, when downspouts are not present, it flows from eaves in concentrated sheet flows and causes erosion. This water is often directed to the storm drain system from downspouts or drip lines, picking up nutrients and sediments on the way. Controlling roof runoff by directing it to vegetated areas, filtering it through bioretention systems, vegetated swales or buffer strips, storing it for irrigation, or allowing for infiltration, reduces the peak flow rates and volume of storm water runoff and associated pollutants loads.

Figure 3-3: A downspout directed to a landscaped area.

Design Considerations

- Downspouts can be directed towards landscaping, vegetated swales, filter strips, bioretention systems, sand filters, infiltration trenches or infiltration basins.
- Roof runoff can also be stored for irrigation by directing downspouts to rainwater collection devices.
- Storm water planters and rock-lined trenches under roofline/dripline can help to control erosion from concentrated sheet flow off of the roof and promote infiltration.
- Plants installed along a building's drip line should be sturdy enough to handle heavy runoff sheet flows from rooftop runoff.
- Splash blocks or gravel splash pads should be used to dissipate runoff energy from downspouts.

3.1 MINIMIZING AND DISCONNECTING IMPERVIOUS SURFACES

- Appropriate for most single-family homes and multi-family developments, commercial and industrial areas.
- Can be applied in areas of new development or in areas of redevelopment.
- Rain barrels and cisterns must be securely covered to prevent vector breeding.
- Rain barrels and cisterns must be child proof.

Limitations

- Plantings under rooflines must be able to withstand heavy runoff sheet flows and soil saturation.
- Soil permeability may limit applicability of infiltration trenches.
- An uncovered rain barrel or cistern can provide mosquito habitat if it contains standing water.

Maintenance Considerations

- Routine landscape maintenance required for plantings located under rooflines and around downspouts.
- Inspect and maintain rain barrels and cisterns at least twice a year to ensure they are secure, functioning properly, and not breeding mosquitoes.

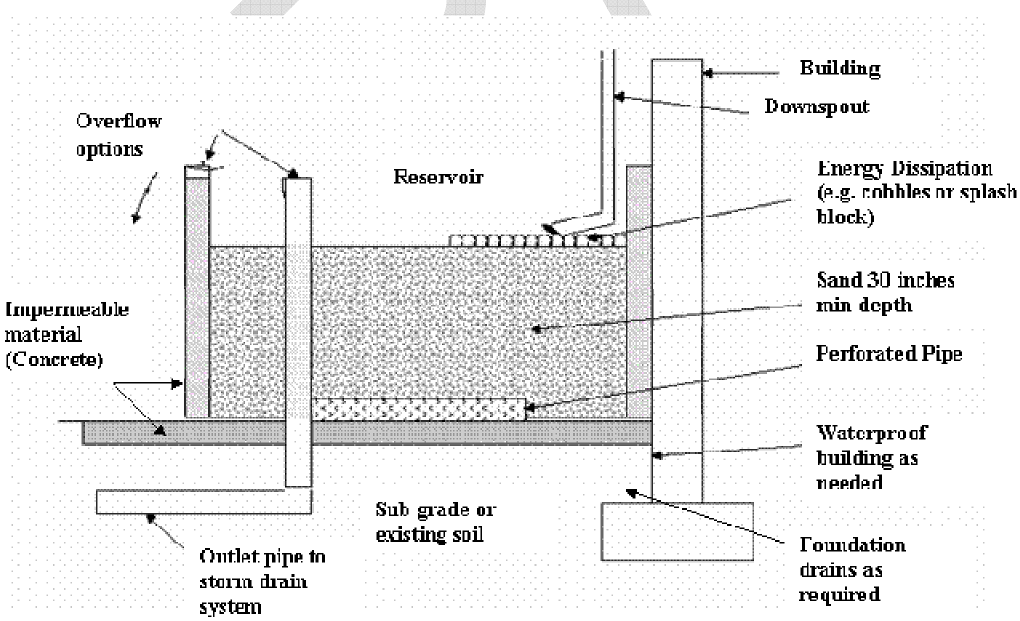

Figure 3-4: E□ample of a sand filter for roof runoff control (modified from Portland, 2000).

3.1 MINIMIZING AND DISCONNECTING IMPERVIOUS SURFACES

3.1.1 Pavement Disconnection

In conventional development, impervious pavement in parking lots, streets, roads, highways, freeways, driveways, sidewalks and bike paths are often directly connected to each other and the storm drain system. Disconnecting pavement by designing runoff to sheet flow onto adjoining vegetated areas or porous pavement before it reaches the storm drain system reduces the rate, volume and pollutant loading of urban runoff. Urban runoff slows as it travels though vegetation or over a porous surface and water is infiltrated into the soil where the majority of pollutant removal occurs. The following sections present alternative LID designs for parking lots, streets and roadways, driveways, sidewalks and bike paths that have been shown to effectively reduce runoff and pollutants in storm water.

3.1.2 LID Parking Lot Design

Parking lots contribute a sizeable area of impervious coverage to urban developments and are significant sources of storm water runoff and the discharge of associated pollutants to the storm drain system and local surface waters. Several strategies can be implemented to mitigate this impact, including reducing impervious surfaces using permeable paving alternatives in overflow parking areas and landscaped detention (bioretention) basins installed in parking lot islands and perimeter landscaping.

Managing Runoff

Storm water management in parking lots can mimic natural hydrologic functions by installing design features that capture, treat, and infiltrate storm water runoff rather than conveying it directly into the storm drain system. Management options include:

- Landscaped detention and bioretention areas (Figure 3-5) can be installed within and/or at the perimeter of parking lots to capture and infiltrate runoff. These include permeable landscaped areas designed with grades below the impervious parking surface and can be delineated by flat concrete curbs, shrubs, trees or bollards.

Figure 3-5: Parking lot bioretention

(photo from ToolBase Services)

Figure 3-6: Parking lot made of a permeable paving surface

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- Porous surfaces can be installed in down gradient parking stalls and in overflow parking areas (Figure 3-6). Permeable materials that can be utilized include permeable pavers, porous asphalt, and porous concrete (see section 3.4). In some circumstances, gravel or wood chips can also be used.
- Storm water runoff from the top floor of parking garages can be drained to planter boxes located at the perimeter of the parking lot or at street level.

Reducing Impervious Surfaces

Research has shown that zoning regulations typically require more parking spaces than are needed. Parking lot size is usually based on peak demand rather than average usage. Parking codes should be reviewed and revised to reduce parking minimums. Parking codes should also be revised to allow shared parking for businesses with different hours of peak demand. Bus and shuttle services can be provided between commercial centers that only experience peak demands during holidays and parking areas such as government facilities and schools that are typically vacant over holidays. Other strategies that can also be implemented to reduce the total parking area include compact parking spaces, a reduction in stall dimensions, and determining the most space-efficient design for parking spaces (e.g. angled or perpendicular). Consideration should be given to design options such as underground parking or multi-storied garages. As noted above, vegetation and landscaping can be designed to intercept rainfall and capture storm water. Including trees in parking lot landscaping should also be considered. In addition to reducing impervious coverage and providing tree canopy to intercept rainfall, trees reduce the urban heat island effect of parking lots by shading heat-adsorbing surfaces.

Design Considerations

- Revise parking ratio requirements.
- Utilize minimum stall dimensions and compact parking spaces. In larger commercial lots, 30 percent compact parking spaces is suggested.
- Use porous concrete, porous asphalt or permeable pavers in overflow parking areas or down gradient parking stalls (e.g. at areas located at low points in the parking lot).
- Utilize the most space-efficient design for parking stalls.
- Utilize vegetation and landscaping for capture and infiltration of rainfall and storm water runoff, for impervious surface reduction, and for shading.
- Utilize flat curbs or curb cuts (Figure 3-7) to direct runoff into landscaped areas.

Limitations

- Existing parking requirements and codes can limit the use of LID techniques.

Maintenance Considerations

- Regular maintenance of landscaped areas is required.
- Irrigation of landscaped areas may be required.

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- In areas receiving snowfall, to avoid excessive accumulation of sediments, snow should not be regularly stockpiled in landscaped detention areas.

Figure 3-□: Curb cuts direct water into t□is par□ing lot bioretention system.

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Examples

1. Based on construction cost estimates provided by the City of Reno, NV, storm drainage systems for parking lots with landscape detention (bioretention) basins installed in well draining soils would be expected to cost approximately 50% less than conventional storm drainage systems. Landscape detention basins installed in well draining soils typically do not include underdrain systems and only a limited amount of conventional storm drain infrastructure. Conventional storm drain infrastructure, such as catch basins and underground concrete pipe, are often one of the most expensive items in conventional parking lot construction. When landscape detention basins are installed in poorly draining soils, such as soils with a high silt or clay content, LID parking lot storm drainage system costs are comparable to conventional parking lot storm drainage system costs. However, conventional parking lot storm drainage systems increase the rate and volume of storm water runoff, and the associated pollutant loads to receiving waters. Whereas LID parking lot storm drainage systems reduce the storm water runoff and pollutant loads produced by the impervious surfaces of parking lots.

2. The Morton Arboretum in DuPage County, Illinois is a 1,700+ acre outdoor museum of woody plants adjacent to Meadow Lake and the East Branch of the DuPage River. When a new visitor center was proposed for the facility a “green” parking lot was constructed to accommodate the anticipated increase in visitation.

   A concrete paver system was utilized for the parking lot based on their durability and high strength to withstand heavy traffic loading. Biofiltration swales were designed along 9-foot medians in the parking lot to capture and infiltrate runoff from the parking lot. Perforated storm sewers were utilized along the length of each biofiltration swale so that run-off entering the storm sewer could have a chance to infiltrate back into the ground. A control structure was installed at the downstream end of the system to restrict flows and allow more time for water to infiltrate into the ground, which is removable in case the sub-base becomes overly saturated. Also utilized were grassy filter strips, created wetlands, vegetated channels, and vortex-type oil traps.

After a year of use the paving system is functioning properly with a 2-year study currently underway to determine the effects of this parking lot and the combination of the BMP's utilized. Funding for this project was largely obtained through grant funding from the EPA. (Kelsey and Sikich, 2005)

References and Additional Sources of Information

Bay Area Stormwater Management Agencies Association (BASMAA). 1999. *Start at the Source: Design Guidance Manual for Stormwater Quality Protection.* Prepared by Tom Richman & Associates. www.basmaa.org

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3.1 MINIMIZING AND DISCONNECTING IMPERVIOUS SURFACES

3.1.3 LID Street and Road Design

Streets and roads include a significant portion of impervious coverage in a community and are one of the largest contributors of storm water flows and pollutant loads. LID street and road design is a strategy to curb this impact by reducing impervious coverage and maximizing storm water infiltration and pollutant uptake.

Elements of LID Street and Road Design

- Road layout – consider alternatives that reduce impervious coverage, reducing the length of the road network by exploring alternative street layouts. Clustering homes and narrowing lot frontages can reduce road length by reducing the overall development area. Another approach is to lengthen street blocks and reduce cross streets, providing pedestrian and bicycle paths mid-block to increase access.

- Street width – determine based on a function of land use, density, road type, average daily traffic, traffic speeds, street layout, lot characteristics and parking, drainage and emergency access needs.

- Cul-de-sac design – cul-de-sacs create large areas of impervious coverage in neighborhoods. Alternatives to the traditional cul-de-sac that can reduce impervious coverage include landscaped center islands with bioretention (shown in Figure 3-8), reduction of the radius to 30 feet, a T-shaped hammerhead design, or a loop road network.

Figure 3-□: Landscaped cul-de-sac

- Right-of-way – should reflect the minimum required to accommodate the travel lane, parking, sidewalk, and vegetation, if present.

- Permeable materials – use in alleys and on-street parking, particularly pull out areas.

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3.1 MINIMIZING AND DISCONNECTING IMPERVIOUS SURFACES

- Increased access – create paths to open space and other streets for pedestrians and bicyclists in subdivisions where alternative street layouts such as loop networks and cul-de-sacs are utilized.

- Traffic calming features – traffic circles, chicanes, chokers, speed tables, center islands, and speed humps offer the opportunity for storm water management through the use of bioretention areas or infiltration within these areas while providing pedestrian safety.

Drainage Options

Maximize drainage – preserve natural drainage patterns and avoid locating streets in low areas or highly permeable soils.

Uncurbed roads – where feasible, build uncurbed roads using vegetated swales as an alternative (Figure 3-9).

Urban curb/swale system – runoff runs along a curb and enters a surface swale via a curb cut, instead of entering a catch basin to the storm drain system.

Dual drainage system – a pair of catch basins with the first sized to capture the water quality volume into a swale while the second collects the overflow into a storm drain.

Concave medians – median is depressed below the adjacent pavement and designed to receive runoff by curb inlets or sheet flow. Can be designed as a landscaped swale or a biofilter.

Figure 3-: An uncurbed road utilizing a vegetated swale

Benefits of LID Street Designs

- Storm water runoff is reduced.
- Narrower streets slow traffic and increase pedestrian, bicycle and driver safety.
- Less runoff generated from decreased impervious surfaces creates a reduction in storm water runoff, which may result in a decrease in expenses in storm water management structures and treatment.
- Paving costs of street network are reduced.

3.1 MINIMIZING AND DISCONNECTING IMPERVIOUS SURFACES

Design Considerations

- Reduce the length of residential streets by reviewing minimum lot widths and exploring alternative street layouts.
- When siting streets, consider natural drainage patterns and soil permeability.
- Consider access for large vehicles, equipment, and emergency vehicles when designing alternative street layouts and widths.
- Impervious cover created by each cul-de-sac turnaround option is presented below. (Schueler, 1995)

Turnaround Option	Impervious Area (square feet)
40-foot radius	5,024
40-foot radius with island	4,397
30-foot radius	2,826
30-foot radius with island	2,512
Hammerhead	1,250

Limitations

- Local zoning standards may require wide streets, sidewalks on one or both sides of streets, and curbed roads.
- Arterial, collector and other street types with greater traffic volumes are not candidates for narrower streets.
- Street width and turnaround design need to accommodate fire trucks and other large vehicles and equipment.

Maintenance Considerations

- Narrower streets should require less maintenance than wider streets as they present less surface area to maintain and repair.
- Landscaped and bioretention cul-de-sacs and traffic calming areas will require routine maintenance associated with these areas.

Examples

In Seattle, WA, a pilot project, Street Edge Alternatives Project (SEA Streets), attempts to mimic pre-developmental hydrologic conditions by reducing impervious surfaces by 11 percent less than a traditional street, incorporating LID principles such as reducing on-street parking, narrowing street widths, reducing sidewalks, eliminating curbs and gutters by providing surface detention in swales, and adding 100 evergreen trees and 1,100 shrubs. One of the most prominent features of the project is the 14-foot wide curvilinear streets, which is wide enough for two standard size cars to pass each other slowly (Figure 3-10). The edge of the roadway has no curb and has a two-foot grass shoulder capable of bearing traffic loading to accommodate emergency vehicle passage. Parking stalls are grouped between swales and driveways with the number of spaces determined by homeowner needs. The sidewalk also follows a curvilinear

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design and is only located on one side of the street. Swales are located in the right of way adjacent to the street to capture runoff from the street, sidewalk and adjacent property. After two years of monitoring, the project has reduced the total volume of storm water leaving the street by 98 percent for a two-year storm event. (Seattle Public Utilities District, 2003)

Figure 3-10: Images of SEA Project streets (images courtesy of Seattle Public Utilities District)

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3.1 MINIMIZING AND DISCONNECTING IMPERVIOUS SURFACES

3.1.4 LID Driveway Design

Driveways add a significant amount of impervious coverage to a community and are an element of a site's design that can be altered to minimize total impervious coverage. Driveways often slope directly to the street and storm drain system and contribute significantly to storm water pollution. There are several strategies that can be implemented to reduce this impact, including:

- Utilize shared driveways to provide access to several homes.
- Reduce driveway length by reducing front yard setbacks.
- Reduce driveway width by allowing tandem parking (one car in front of the other).
- Install a narrowed driveway with a flared entrance for multi-car garage access.
- Disconnect the driveway by directing surface flow from the driveway to a permeable landscaped area, such as a below grade bioretention basin.
- Consider ribbon driveways, which consist of two strips of pavement with grass or some other permeable surface in between the strips.
- Utilize porous surfaces such as porous concrete or asphalt, permeable pavers or crushed aggregate.
- Create a temporary parking area where parking or access is infrequent. These areas can be paved with permeable surfaces.

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Figure 3-11: This driveway is designed with multiple LID strategies including permeable pavers and a slotted drain built in to catch sediment and runoff which is funneled into a grassy swale.

(Photo courtesy of NEMO Nevada)

Design Considerations

- Shared Driveways:
  - Shared driveways can provide access to several homes.

  - Access may not need to be as wide as residential streets.

- Disconnected Driveways:

  - The driveway cross slope must be greater than the longitudinal slope in order for runoff to be directed into adjacent landscape.
  - Adjacent landscape must be sized to accommodate the water quality volume.
  - The edge of the driveway must be approximately 3 inches above the vegetated area so to not impede flow from the driveway.
  - A slotted channel drain is installed at or below the surface of the driveway roughly perpendicular to the flow path, captures flow from driveway and directs it to an infiltration system or vegetated area. Should have removable grates to allow access for cleaning. (See Figure 3-12)

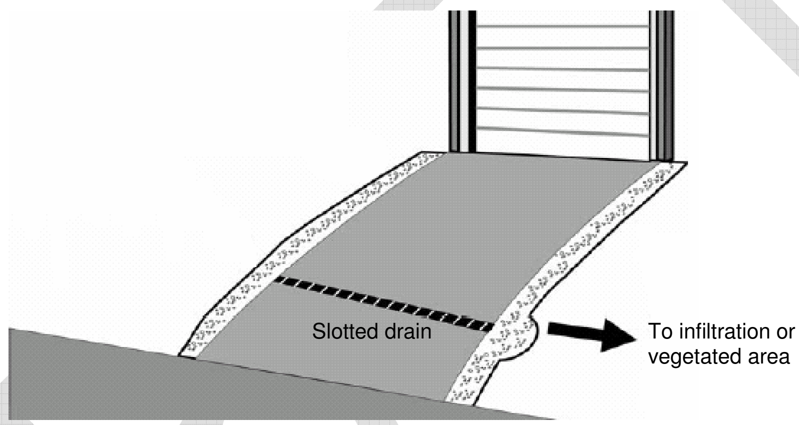

Figure 3-12: A schematic of a driveway containing a slotted drain.
(adapted from BMP Retrofit Partners, 2003)

- Ribbon Driveways (Figure 3-13):

  - Wheel tracks should be wide enough to accommodate variability in driving and vehicle widths.
  - For soils with low infiltration rates, a perforated drain line buried between the wheel tracks may be appropriate to collect and direct runoff.
  - If vegetation is incorporated, it should be irrigated.

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3.1 MINIMIZING AND DISCONNECTING IMPERVIOUS SURFACES

(Photo courtesy of NEMO Nevada)

Figure 3-13: Ribbon Driveway also known as a Hollywood driveway.

- Flared Driveways:
  - Single lane width at street with flare at garage to serve multiple garage door openings.
  - Provide adequate space in front of multi-car garage for vehicle parking and maneuvering.
- Crushed Aggregate Driveways:
  - Use open-graded crushed aggregate rather than rounded stones.
  - Utilize a rigid edging material such as wood, concrete, metal, or brick to contain aggregate material.

Limitations

- Driveway length is generally determined by front yard setback requirements.
- Driveway width is usually mandated by municipal codes.

Maintenance Considerations

- For driveways connected to landscaped areas, maintenance and edging of the adjacent lawn is important to allow unimpeded flow.
- For ribbon driveways, the area between the wheel tracks requires edging and maintenance, including periodic weed control.
- Crushed aggregate driveways may require periodic weed control and replenishment of the aggregate.
- Slotted channel drains generally need to be cleaned twice a year, in the spring and fall, and should be swept or vacuumed out. Clear any loose surface debris on a regular basis. The outlet should be checked periodically for clogging.

3.1 MINIMIZING AND DISCONNECTING IMPERVIOUS SURFACES

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3.1.5 LID Sidewalks and Bike Paths

Sidewalks and bike paths are another source of impervious coverage that can adversely affect water quality by the runoff generated from their surface. Several management opportunities and strategies are available to reduce this impact, including:

- Reducing sidewalks to one side of the street.
- Disconnect bike paths from streets. Bike paths separated from roadways by vegetated strips reduce runoff and traffic hazards.
- Utilizing pervious materials to infiltrate or increase time of concentration of storm flows (Figure 3-14).
- Reducing sidewalk width when possible.
- Directing sidewalk runoff to adjacent vegetation to capture, infiltrate, and treat runoff.
- Installing a bioretention area or swale between the street and sidewalk and grading runoff from the sidewalk to these areas (see section 3.1.3).
- Planting trees between the sidewalk and streets to capture and infiltrate runoff.
- Installing grated infiltration systems in sidewalks and bike paths to receive runoff as sheet flow. These can be installed to protect trees or can provide off-line storm water management via a grate over an infiltration trench.

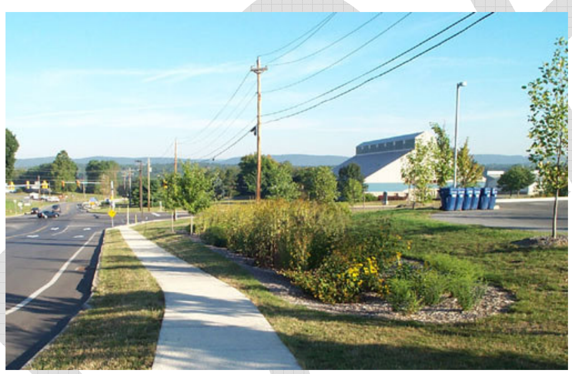
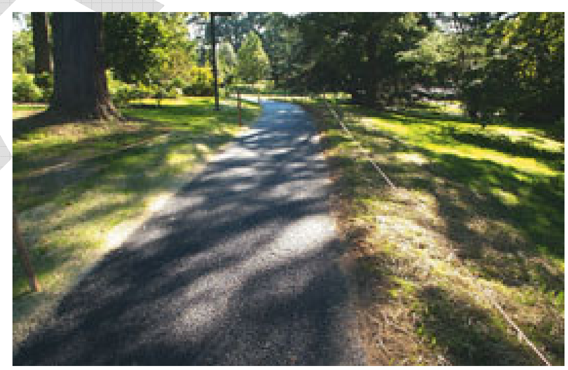

Figure 3-14: The sidewalk on the left is made of porous concrete and the walkway on the right is made of porous asphalt. (Photos courtesy of [Cahill Associates] and [Stormwater Journal])

Design Considerations

- Grade sidewalks and bike paths at a two percent slope to direct runoff to an adjacent vegetated area.
- Pervious materials such as permeable pavers, porous concrete or asphalt, gravel, or mulch can be utilized for sidewalk surfaces.
- In some cases, sidewalks and bike paths can be placed between rows of homes to increase access and decrease overall effective imperviousness.

3.1 MINIMIZING AND DISCONNECTING IMPERVIOUS SURFACES

- Grated infiltration systems should include removable grates to allow for maintenance, and must be capable of bearing the weight of pedestrians.

Limitations

- Ordinances may require sidewalks on both sides of the street.
- Groundwater table must not be within 10 feet of the bottom of infiltration trenches.
- Bioretention or swales may require supplemental irrigation.
- Vector breeding may occur in bioretention and swales if not properly designed or maintained.

Maintenance Considerations

- For maintenance of pervious surfaces, including porous concrete and asphalt and permeable pavers see section 3.4.
- For maintenance of bioretention areas see section 3.3.
- For maintenance of swales see section 3.2.

Examples

As also described in Section 3.1.3 and also shown on Figure 3-15, the Seattle, WA Street Edge Alternatives (SEA) Streets project, attempts to mimic pre-developmental hydrologic conditions by reducing impervious surfaces 11 percent less than a traditional street, incorporating LID principles such as reducing on-street parking, narrowing street widths, reducing sidewalks, eliminating curbs and gutters by providing surface detention in swales, and adding 100 evergreen trees and 1,100 shrubs. After two years of monitoring, the project has reduced the total volume of storm water leaving the street by 98 percent for a two-year storm event. (Seattle Public Utilities District, 2003)

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Figure 3-15: Images of SEA Pro□ect streets sidewal□s (images courtesy of Seattle Public Utilities District)

3.1 MINIMIZING AND DISCONNECTING IMPERVIOUS SURFACES

References and Additional Sources of Information

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3.2 Swales and Filter Strips

Swales and filter strips can be effective storm water treatment control systems if runoff depths are shallow and velocities are slow. These systems rely upon the vegetation and the subsoil matrix to filter pollutants from runoff and can also provide infiltration and groundwater recharge. They can provide desirable open space buffers between developed impervious surfaces, the storm drain system, and receiving water bodies. Wherever possible, swales should be incorporated into natural drainage channels. Vegetative treatment systems such as swales and filter strips reduce the velocity of urban runoff and can serve as part of the storm drain system. They can be accessed by curb cuts or they can replace curbs, gutters and subsurface storm drain pipe systems. Swales sited on existing clayey or silty soils with low infiltration rates (less than 0.5 in/hr or 120 min/in) should also include underdrain systems.

Swales and filter strips can be accessed by grade design, curb cuts, or they can replace curbs, gutters, and subsurface storm drain pipe systems. By designing the grade of impervious surfaces such as driveways and sidewalks to flow towards vegetated areas instead of towards streets, they can be accessed directly. To facilitate flow into these LID practices and accommodate vegetation growth and sediment deposition, the edges of driveways and sidewalks should be designed to be 2 to 5 inches above the adjacent edge of swales and filter strips.

Swales are shallow open channels. Also known as vegetated swales, biofiltration swales or grassy swales, they are commonly vegetated with grasses (Figure 3-16). Rock lined low flow channels and underdrain systems can be added where native soils have poor infiltration characteristics (Figure 3-17) and grades that are less than 0.5 percent. Low flow channels and underdrain systems can reduce the potential of extended ponding and mosquito breeding. Xeriscape swales (Figure 3-18) are planted with native vegetation or low water use plants interspersed among rock and have little to no water requirements once established. Storm water runoff is conveyed along the length of the low slope channel, which decreases the velocity, traps sediments, and reduces erosion. Storm water runoff is treated by filtering sediments and associated pollutants through the engineered subsoil and vegetation and by infiltration into the underlying soils. Pollutant removal and treatment efficiency improves as contact time and the amount of infiltration increases.

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Figure 3-16: Grassy swale

Figure 3-17: Swale with rock lined low flow channel

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3.2 SWALES AND FILTER STRIPS

Grassy and xeriscape swales are simple to design and install. They can serve as part of the storm drain system or can be used in place of curbs and gutters. These practices can also be used with other structural treatment controls and LID practices as part of a treatment train. They can be used to convey and treat runoff from parking lots, buildings, and roadways and can be applied in residential, commercial, industrial, and municipal land uses. Xeriscape swales are recommended wherever possible to assist with water conservation strategies. Grassy swales are appropriate in parks or private landscaped areas that are irrigated.

Figure 3-18: Xeriscape swale.

Figure 3-19: Buffer strip.

Filter strips are also known as vegetated filter strips or buffer strips (Figure 3-19). They are gently sloping and uniformly graded vegetated strips that provide storm water treatment to relatively small drainage areas. Filter strips slow the velocity of runoff to promote filtration of sediments and pollutants and infiltration into underlying soils. They require sheet flow to function properly and often require a flow spreader to evenly distribute runoff across the width of the filter strip. This may be a porous pavement strip or another type of structure. Grassed or vegetated filters consist of uniformly graded, densely vegetated turf surfaces that can be interspersed with shrubs and trees to improve aesthetics and provide shade. In the semi arid climate of the Central Coast, irrigation is typically required for grassy filter strips to maintain a healthy and dense vegetative cover capable of withstanding the erosive forces of runoff from adjacent impervious areas.

Xeriscaped filter strips use the same concept as vegetated filter strips except they incorporate low to no water use plants and rock, allowing for water conservation. Filter strips are typically located on the edge of landscaping areas and can provide pretreatment for other treatment controls. Xeriscape filter strips (Figure 3-18) are ideal at the edge of landscaping features to reduce runoff and conserve water. Lawn areas adjacent to sidewalks, driveways and streets are typically hotter and drier and require more water than areas not adjacent to these impervious surfaces. By planting a xeriscape filter between sidewalks, driveways, and streets and the lawn, water needs will be reduced. Less runoff will also occur as the xeriscape filter strip captures and infiltrates the water leaving the lawn area. This can be particularly useful where lawn areas are located directly downwind of prevailing winds. Studies have shown that up to 40 percent of the water that leaves sprinklers can be lost to overspray, runoff, and evaporation.

3.2 SWALES AND FILTER STRIPS

The recommended plant species for vegetated swales and filter strips should meet the following criteria:

- Native or easily naturalized,
- Low water requirements,
- Low fertilizer requirements,
- Low maintenance requirements, and
- Attractive in all seasons.

Plant species located in the low zone (bottom) of vegetated swales must be able to withstand periodic flooding. Turf or other soil erosion grasses can also be used in vegetated swales (e.g. grassy swales) and buffer strips. However, turf requires regular irrigation, fertilizer application, and maintenance which may result in reduced pollutant removal effectiveness. Fertilizer use should be minimized in vegetated swales and buffer strips. Slow release fertilizers may be used provided it does not become a pollutant in storm water (e.g. never apply fertilizers when rain is predicted). Herbicides and pesticides are also not recommended unless absolutely required. Maintaining mulch and hand-weeding are the recommended weed-control measures. If herbicides are necessary, use natural alternatives such as corn gluten and insecticidal / herbicidal soap or herbicides that degrade quickly such as glyphosphate (e.g. Roundup). If pesticide use is necessary, biological pest and disease controls are recommended. Sources of information for natural pesticide alternatives include the following:

- *Suppliers of Beneficial Organisms in North America*, available from the California Department of Pesticide Regulation, Environmental Monitoring and Pest Management Branch, 830 K Street, Sacramento, CA, 95814, (916) 324-4100.
- *Directory of Least-toxic Pest Control Products,* available from the Bio-Integral Resource Center, P.O. Box 7414, Berkeley, CA, 94707, (510) 524-2567.

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3.2.1 VEGETATED SWALES

3.1.1 egetated Swales

Vegetated swales are also known as biofilters, biofiltration swales, landscaped swales, and grass swales. To be effective at storm water management, vegetative swales should be designed as wide, shallow earthen open channels covered with a dense vegetative growth (commonly grasses) along the bottom and side slopes. Storm water runoff is conveyed along the length of the low slope channel and vegetation traps sediments, decreases the velocity of overland flows, and reduces erosion. Storm water runoff is treated by filtering sediments and associated pollutants through the vegetation and by infiltration into underlying soils. Pollutant removal and treatment efficiency improves as contact time and infiltration increases. For this reason, the length of vegetated swales should not be less than 100 feet.

Vegetated swales are considered an LID practice and are relatively simple to design and install. They can serve as part of the storm drain system or can be used in place of curbs and gutters and can be used with other structural treatment controls as part of a treatment train. Vegetative swales can provide some reduction in peak flows during storm events by slowing the velocity of runoff and depending upon the properties of the underlying soils, they can also facilitate infiltration. However they do not typically reduce post construction flow rates and volumes to the levels required by local ordinances or NPDES storm water permit requirements. Therefore, additional detention, retention and/or infiltration facilities typically may need to be added to vegetated swales to address local, regional, and/or state requirements.

Applications and Advantages

Vegetated swales can be used to convey and treat runoff from parking lots, buildings, roadways, and residential properties. They are typically located in parks, parkways or private landscaped areas (in ROW's) and can also be used as pretreatment devices for other structural treatment controls. They can be designed as natural drainage features with temporary irrigation provided to establish the vegetation and annual maintenance, or they can be designed as landscaped areas with permanent irrigation systems.

Performance Data

The literature reported range of removal for various pollutants is as follows:

Pollutant	Percent Removal Efficiency
Total Suspended Solids	60 – 95%
Total Phosphorus	5 – 45%
Total Nitrogen	15 – 65%
Nitrate	-25 – 65%
Metals	20 – 90%

Sources: UDFCD, 1999; CASQA, 2003

The large range in pollutant removal efficiencies reflects differences in design, variable influent concentration levels and flow rates, and the permeability of underlying soils. Pollutant removal efficiencies for vegetated swales generally increase when underlying soils provide for infiltration.

3.2.1 VEGETATED SWALES

The literature reviewed does not discuss the removal efficiency for organics or petrochemicals. Additional BMPs may be needed for treatment of these pollutants.

Limitations

- Vegetated or grassy swales typically require supplemental irrigation.
- Effectiveness is decreased by compacted soils, frozen ground conditions, short grass heights, steep slopes, large storm events, high discharge rates, high velocities, and a short runoff contact time.
- Requires a sufficient amount of available land area.
- May not be appropriate for industrial sites or locations where spills may occur.
- Infiltration rates of local soils can limit the application of vegetated swales, unless underdrains are installed.
- Effectiveness may be limited in areas where gophers or other burrowing animals are abundant.
- Possible formation of mosquito breeding habitat if water does not drain or infiltrate.

Siting Criteria

- Maximum swale drainage areas is 10 acres. Smaller drainage areas are preferred.
- Not to be applied in areas with adjacent slopes of 5 percent or greater or in areas with highly erodible soils.
- If possible, the preferred installation site is in a natural topographic low to preserve natural drainage and recharge patterns.
- To provide adequate contact time for pollutant removal, generally the minimum length of the swale should be 100 feet.
- Swales should be established with a minimum longitudinal slope of 0.5 percent and a maximum longitudinal slope of 2.5 percent. Swales or swale sections with longitudinal slopes between 2.5 and 5.0 percent may be allowed if check dams are installed to reduce runoff velocity to 2.0 ft/sec or less.
- If designed to infiltrate storm water into underlying soils, swales are considered indirect infiltration systems. Therefore the apply site screening, infiltration testing, separation, and setback standards for indirect infiltration systems presented in Section 4.2.

Design and Construction Criteria

- Registered professional civil engineers and landscape architects should work together on the design vegetated swales.
- Design vegetated swales to convey the Water Quality Flow (WQ_F) rate based on the method presented in Section 4.5.2.
- If possible, flows in excess of the WQ_F rate should be diverted around vegetated swales with upstream diversion structures.

3.2.1 VEGETATED SWALES

- If a swale is be designed to both convey and treat the WQ_F rate and to convey the flows produced by larger storm flows, the swale should be designed to safely convey flows produced by the 100-year storm event.
- Trapezoidal or parabolic channels are recommended.
- Swale side slopes should not be steeper than 4H:1V (see Figure 3-20).
- The minimum bottom width should be no less than 2 feet (see Figure 3-20)
- The maximum bottom width should not exceed 10 ft.
- To size the bottom width, use the Manning's equation at the WQ_F with a roughness coefficient (*n*) value of 0.25 for grass and 0.40 for mixed vegetation and rocks[4].
- Improved pollutant removal efficiency occurs with a minimum 10-minute hydraulic residence time at the WQ_F.
- To determine the capacity of the swale to convey peak hydraulic flows, use a roughness coefficient (*n*) of 0.10 with Manning's Equation.
- A design vegetation height of 4 - 6 inches is recommended.
- A diverse selection of low growing plants that thrive under site specific soils and proposed watering conditions should be specified.
- For areas without regular irrigation, use drought tolerant vegetation, however pollutant removal efficiencies will typically be reduced.
- The swale must meet local ordinances and should be included on site plans.
- The swale must not hold standing water for more than 72 hours to prevent vector problems.
- Effectiveness can be improved by installing check dams at regular intervals.
- A 4-inch diameter PVC under drain should be provided in type C and D soils (e.g. silty or clayey soils) to increase infiltration capacity.
- Fertilizers and soil amendments should be specified based on soil testing results and vegetation requirements. Improper application of fertilizer can result in contamination of stormwater runoff.

Inspection and Maintenance Requirements

- With proper inspection and maintenance, vegetated swales can last indefinitely.
- Proper maintenance includes mowing, weed control, removal of trash and debris, watering during the dry season, and reseeding of non-vegetated areas.
- When mowing grass, never cut shorter than the design flow (WQ_F) depth, and remove grass cuttings.

[4] Manning's roughness coefficient (*n*) values used for open channels have historically ranged from approximately 0.02 to 0.10 (see Table 3-2). However, these values were applied to channels designed to efficiently and quickly transport water. For vegetated swales designed to treat storm water quality, higher *n* values should be applied (Minton, 2006).

- Inspect swales at least twice annually for damage to vegetation, erosion, sediment accumulation and ponding water standing longer than 72 hours.
- Periodic litter collection and removal will be necessary if the swale is located adjacent to a main road.
- Sediments should be removed when depths exceed 3 inches.
- If a spill occurs and hazardous materials contaminate soils in vegetated swales, the affected areas should be removed immediately and the appropriate soils and materials replaced as soon as possible.

Examples

The Morton Arboretum in DuPage County, Illinois is a 1,700+ acre outdoor museum of woody plants adjacent to Meadow Lake and the East Branch of the DuPage River. When a new visitor center was proposed for the facility a "green" parking lot was constructed to accommodate the anticipated increase in visitation. The parking lot utilized biofiltration swales as parking lot medians to drain the parking lot. Also utilized were grassy filter strips, permeable pavement, created wetlands, vegetated channels, and vortex-type oil traps.

The biofiltration swales were designed along 9-foot wide medians in the parking lot with a barrier curb along the swales that incorporated 3-foot gaps to minimize the amount of concentrated flow into the swales. The curb cuts were spaced 3 stalls apart and located along parking lot stripes to avoid the potential for small vehicles or motorcycles from driving into the swales. Curb structures were specially graded with the gutter being pitched from the middle to slope at approximately 0.5 percent to the curb cut.

The swales were constructed to pond to a depth of 0.5 ft prior to overflowing to the conventional storm drain system. Side slopes were graded at a 3 H:1V slope, being approximately 1 foot below the edge of the pavement, and having a 3-foot bottom width. The soil consisted of a sandy loam mix with approximately 5 percent coarse organic matter.

After a year of use, the parking lot biofiltration swales appear to be functioning properly. The only concern is utilization by pedestrians through some of the curb cuts. It is believed that through proper plantings and the installation of stepping-stones this problem can be mitigated. Funding for this project was largely obtained through a grant from the USEPA (Kelsey and Sikich, 2005).

References

California Stormwater Quality Association (CASQA), 2003. California Stormwater Best Management Practice Handbook, New Development and Redevelopment.

City of Livermore, 2003. South Livermore Valley Specific Plan, Residential Street Parkway and Swale Area Planting Policies and Standards.

City of Livermore, 2005. Bioswale Design Guidance Standard Detail No. L-21.

City and County of Sacramento, 2000. Guidance Manual for Onsite Stormwater Quality Control Measures, Sacramento Stormwater Management Program.

3.2.1 VEGETATED SWALES

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Urban Drainage and Flood Control District (UDFCD), 1999. Urban Storm Drainage Criteria Manual, Volume 3 – Best Management Practices. Denver, Colorado.

3.2.1 VEGETATED SWALES

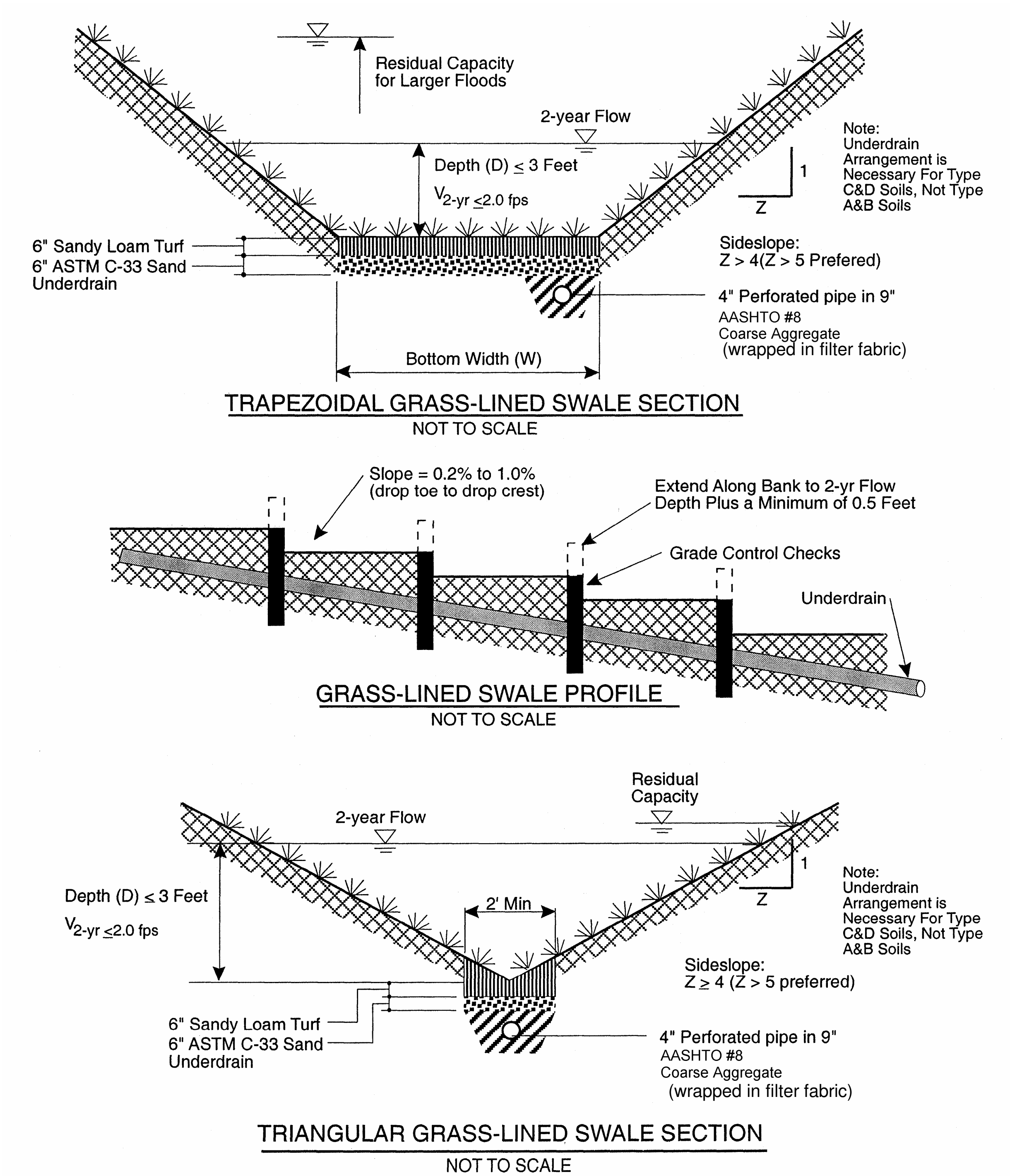
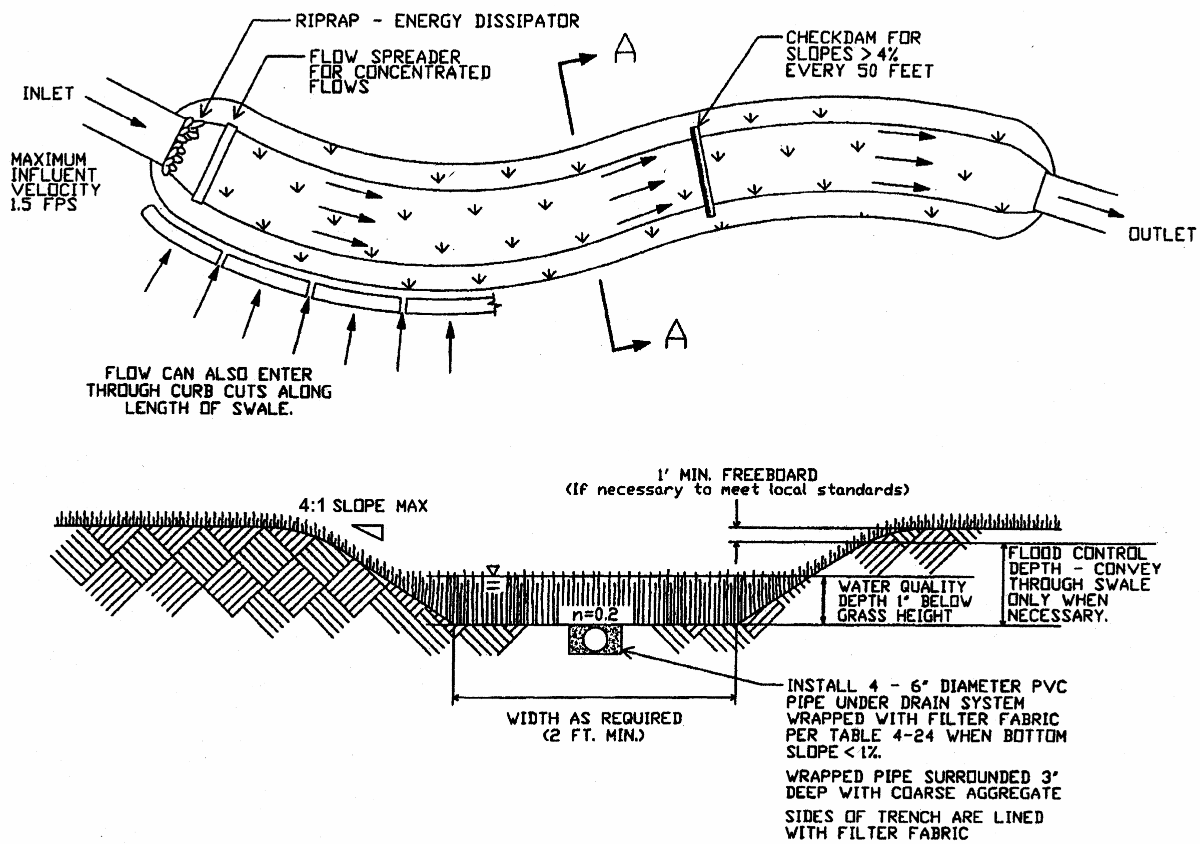


Figure 3-20: Typical design and structure of a Vegetated Swale (modified from UDFCD, 1999).

3.2.1 VEGETATED SWALES



NOTES:

1. An energy dissipator and flow spreader should be installed at the entrance to the swale to reduce velocity and evenly distribute flows across the swale.
2. Maximum allowable side-slope 4H:1V
3. Grass height maintained in accordance with design specifications. Design grass height between 4 to 6 inches.
4. Flow height to be one-inch below design grass height for water quality design storm flow (2 year - 6 hour storm). Use a Mannings roughness coefficient of 0.2 to design for water quality flow through the swale vegetation.
5. n value above water quality height determined based on type of vegetation used. Typical value: 0.035
6. If the swale bottom slope exceeds 4% or soils very permeable, install check dams every 50 feet to slow the velocity to prohibit scouring and promote infiltration.
7. If the swale bottom slope is less than 1% install under drain system to prevent standing water.
8. Flows in excess of water quality flow should be diverted around the swale. If necessary for swale to convey flood waters, provisions shall be made to ensure conveyance in accordance with City or County Standards. Provide 1 ft. freeboard if necessary for flood control.

Figure 3-21: eneral design guidelines for a typical egetated Swale (modified from Sacramento, 2000).

3.2.2 VEGETATED FILTER STRIPS

3.1.2 □egetated Filter Strips

Also known as buffer strips, or grassed buffers, vegetated filter strips consist of dense turf surfaces that can be interspersed with shrubs and trees to improve aesthetics and provide shade. They are gently sloping and uniformly graded and provide storm water treatment to relatively small drainage areas. Vegetated filter strips slow the velocity of runoff waters to promote infiltration and the filtration of sediments and pollutants. They require sheet flow to function properly and often require a flow spreader to evenly distribute runoff across the width of the filter strip. Vegetated filter strips can be used as pretreatment devices for other treatment controls and can also be combined with riparian zones for treating sheet flows and stabilizing channel banks adjacent to drainageways and receiving water bodies. Irrigation is typically required to maintain a healthy and dense vegetative cover capable of withstanding the erosive forces of runoff from adjacent impervious areas.

Applications and Advantages

Vegetated filter strips are appropriate along the edge of residential and commercial developments where irrigated landscaping is planned. They are commonly applied along roadside shoulders in humid areas and have historically been used in agricultural practices.

Performance Data

The literature reported range of removal for various pollutants is as follows:

Pollutant	Percent Removal Efficiency
Total Suspended Solids	10 - 74
Total Phosphorus	0 - 10
Total Nitrogen	0 - 15
Total Recoverable Zinc	0 - 10

Sources: UDFCD, 1999; CASQA, 2003.

Pollutant removal depends on factors such as soil permeability, land uses and slopes of adjacent drainage area, runoff volumes and velocities, the flow path across the filter strip and the type and density of the vegetation used. The general pollutant removal efficiency for both particulate and soluble pollutants is low to moderate.

Limitations

- Typically requires supplemental irrigation.
- A uniformly graded thick vegetative cover is required to function properly.
- May not be applicable adjacent to industrial sites or locations where spills may occur.
- Filter strips are not capable of treating storm water from large drainage areas.
- It may be difficult to establish the level slopes necessary for filter strips.
- Sheet flow is required.

3.2.2 VEGETATED FILTER STRIPS

- Drainage area is limited due to the sizing requirements for a filter strip.
- Cannot be applied in areas with highly erodible soils.

Siting Criteria

- Avoid areas that are highly trafficked, both by automobiles and people.
- Limited to areas with gently sloping surfaces where vegetation is hearty and shallow flow occurs.
- Best suited for treating runoff from roads, roofs, small parking lots, and pervious surfaces.
- Impractical in highly urban areas with little pervious ground.
- Vegetated filter strips do not increase water temperatures and thus are useful for protecting cold-water streams.
- If designed to infiltrate storm water into underlying soils, filter strips are considered indirect infiltration systems. Therefore the apply site screening, infiltration testing, separation, and setback standards for indirect infiltration systems presented in Section 4.2.

Design and Construction Criteria

- A conceptual design can be found on Figure 3-22.
- Registered professional civil engineers and landscape architects should work together on the design vegetated filter strips.
- Slopes should not be greater than 4 percent (2 to 4 percent is preferred).
- Maximum drainage area is 5 acres.
- Sheet flow must be maintained across filter strips.
- To create sheet flows install a level spreader at the top edge of the filter strip along a contour. A porous pavement strip may be used to create sheet-flow conditions.
- Channelized flow across filter strips should not be permitted.
- The top of the vegetated filter strip should be installed 2 – 5 inches lower than the impervious surface that is being drained.
- If supplemental irrigation is not available, use drought tolerant species in the filter strip to minimize irrigation in dry climates.
- If seeds are used to plant the vegetated filter strip, they will need to be protected with mulch for a minimum of 75 days.
- The hydraulic load should not exceed 0.05 cfs/linear foot of the vegetated filter strip during the 2-year storm (WQ_F) to maintain a sheet flow of 1 inch or less trough dense grass that is at least 2 inches high.
- The minimum length of a vegetated filter strip (normal to flow) should be determined using the following equation:

$$L_G = WQ_F / 0.05$$

Where: L_G = minimum design length (ft)

WQ_F = water quality flow (cfs)

- The minimum width of a vegetated filter strip (in the direction of flow) should be determined based on the flow conditions upstream of the filter strip.
- For a sheet flow control level spreader, use the following equation:

$$W_G = 0.2L_L \text{ or 8 feet (whichever is greater)}$$

Where: W_G = width of the filter strip

L_L = the length of the flow path over the upstream impervious drainage area (ft)

- For a concentrated flow control level spreader, use the following equation:

$$W_G = 0.15(A_t / L_t) \text{ or 8 feet (whichever is greater)}$$

Where: A_t= the drainage area (ft^2)

L_t = the length of the drainage area (normal to flow) adjacent to the filter strip (ft)

- Increasing the width (W_G) will increase runoff contact time, filtration of particulates and pollutants, and infiltration of runoff.
- A vegetated swale can be used to collect outflow from a filter strip and can provide additional treatment prior to conveying flows to the storm drain system or receiving waters.

Inspection and Maintenance Requirements

- Required maintenance includes weed removal as well as mowing and irrigation of grasses.
- Grasses or turf should be maintained at a height of 2 – 4 inches.
- Filter strips should be irrigated during the dry season.
- Trash, litter, rocks, and branches should be frequently collected from filter strips, especially those located along highways.
- Regularly inspect filter strips for pools of standing water that may be acting as mosquito breeding habitat.
- Filter strips should be inspected at least two times a year, preferably before and after the winter/wet season.
- Sediments that accumulate along the upstream edge of filter strips and/or in level spreaders should be collected and removed at least once a year.
- The owner/operator of the property must be responsible for maintaining vegetated filter strips.
- If a spill occurs and hazardous materials contaminate soils in vegetated filter strips, the affected areas should be removed immediately and the appropriate soils and materials replaced as soon as possible.

3.2.2 VEGETATED FILTER STRIPS

References

California Stormwater Quality Association (CASQA), 2003. Stormwater Best Management Practice Handbook, New Development and Redevelopment.

Idaho Department of Environmental Quality, 2001. Catalog of Stormwater Best Management Practices: For Idaho Cities and Counties. BMP #39 – Vegetative Filter Strip. http://www.deq.state.id.us/water/stormwater_catalog/doc_bmp39.asp

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3.2.2 VEGETATED FILTER STRIPS

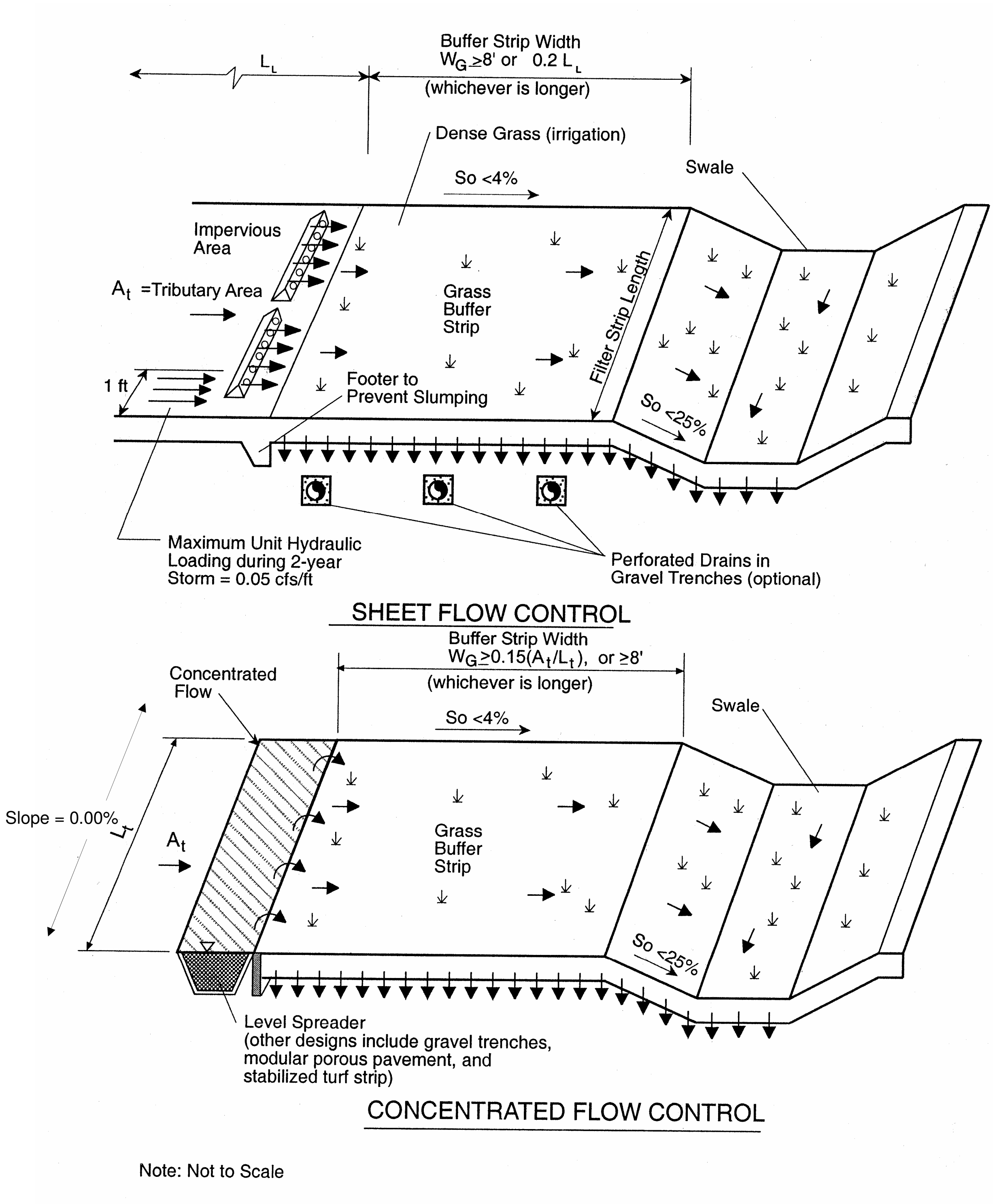

Figure 3-22: □eneral design guidelines for a typical □egetated Filter Strip (modified from UDFCD, 1999).

3.3 Bioretention Systems

Bioretention systems consist of vegetated areas with engineered soils and underdrain systems that capture and treat urban storm water runoff. Bioretention systems are also known as landscape detention, rain gardens, tree box filters, and storm water planters. This type of BMP utilizes a combination of soils and plants to remove pollutants from urban storm water runoff through physical, chemical and biological processes. A typical bioretention system design includes a depressed ponding area, a topsoil or mulch layer, an engineered soil mix of clean sand, peat or leaf compost, and a gravel sub-base layer with an underdrain system consisting of a perforated pipe in a gravel layer. A vegetated swale or buffer strip can be added to provide pretreatment. Urban storm water runoff from upgradient washing and irrigation activities and relatively small storm events passes through pipes, slotted curbs curb cuts or curb inlets and distributes it evenly along the length of the ponding area. Urban runoff ponded from approximately 6 to 12 inches gradually infiltrates into the underlying soils, is evapotranspired, or drains into an underdrain system over a period of days. Excess runoff from large storm events must be allowed to bypass bioretention systems and flow towards the conventional storm drain system. This can be accomplished by providing overflow outlets such as a standard storm drain inlet and/or grade control features.

Applications

Bioretention systems can be incorporated into all aspects of urban development, including residential, commercial, and industrial areas. They are well suited for planters along buildings, street median strips, parking lot islands, and roadside areas. In addition to providing significant water quality benefits, bioretention systems can provide shade and wind breaks, absorb noise, improve an area's aesthetics, reduce irrigation needs, and reduce or eliminate the need for an underground storm drain system. Bioretention systems may be integrated into a site's overall landscaping. Designers may use existing natural surface depressions and swales on the site.

Performance Data

The literature reported range of removal for various pollutants is as follows:

Pollutants	Percent Removal Efficiency
Total Suspended Solids	75 - 90
Total Phosphorus	70 - 80
Total Nitrogen	65 - 80
Total Zinc	75 - 80
Total Lead	75 - 80
Organics	75 - 90
Bacteria	75 - 90

Sources: CASQA, 2003; UDFCD, 1999.

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3.3 BIORETENTION SYSTEMS

These LID practices must be engineered with porous soils mixed with organic matter (peat, topsoil, and certified or leaf compost), and can be designed with or without a gravel sub-base and a permeable filter fabric liner or pea gravel. To conserve water, bioretention systems should be planted with drought tolerant shrubs and grasses. When the infiltration rates of native soils are slow (less than 0.5 in/hr), landscape detention areas and rain gardens typically require underdrain systems to drain properly. They should be designed to capture runoff from developed impervious surfaces and mimic pre-existing hydrologic conditions. The upper surface of bioretention systems is located below the grade of the surrounding impervious drainage area and temporary shallow ponding occurs as water is conveyed through the system.

Storm water and urban runoff filter through engineered soils and plant root structure, removing the majority of pollutants before infiltrating into native soils, draining to an underdrain system, or evaporating. In dry climates a large percentage of the water captured by bioretention systems is held in the pore spaces of the engineered soil matrix and lost to plant uptake and evaportranspiration. Therefore these LID practices can effectively reduce both the volume and rate of runoff from developed areas, and can provide significant project cost savings by reducing the required size and quantity of conventional storm drain infrastructure. They can also reduce the need for downstream storm drain system improvements and assist with water conservation efforts by reducing landscaping irrigation needs.

Figure 3-23: Bioretention systems located on-lot (left) and in a street rig□t of way in residential developments (rig□t).

Bioretention systems can be integrated into a site's overall landscaping and typically require the same routine maintenance as any landscaped area as shown on Figures 3-23 through 3-27). They are suitable for residential, commercial, industrial, and municipal development and redevelopment and can be applied in various settings including:

- Parking lot islands
- Parking lot perimeters – curbless or curbed with curb cuts
- Tree wells and tree box filters – boxed bioretention cells placed at the curb typically just upstream of storm drain inlets
- Within right-of-ways along roads
- Street median strips
- Driveway perimeters

3.3 BIORETENTION SYSTEMS

- Cul-de-sacs
- Landscaped areas in apartment complexes and multifamily housing
- Landscaped areas in commercial, industrial, and municipal developments
- Residential on-lot bioretention – landscape detention or rain gardens
- Planters at rooftop eaves
- Rooftop gardens, particularly on large commercial structures and parking garages

Figure 3-24: Parking lot island bioretention

Figure 3-25: Tree box filter

Figure 3-26: Roadway right-of-way bioretention

Figure 3-2□: Residential on-lot bioretention

Figures 3-24 through 3-27 present various landscape detention / bioretention design scenarios, which vary depending on underlying soils and land uses in the drainage area. Landscape detention installed in well draining native soils with infiltration rates of 0.5 in/hr (120 min/inch) or greater can be installed with no underdrain. NRCS Type A and B soils (see Section 4.1) are typically well draining soils with good infiltration characteristics. The temporary ponding area in bioretention systems must be designed to retain the water quality volume (WQ_V) determined using the method outlined in Section 4.5.1. As discussed in detail in Section 4.4.0, engineered soils consisting of a mixture of 50-60% clean sand, 20-30%% topsoil and 5-20% peat or certified compost should be installed to a minimum depth of 18 inches beneath the temporary ponding area. A layer of clean coarse aggregate can be installed beneath the engineered soils and a permeable filter fabric liner or a layer of pea gravel can be installed at the top and bottom of the gravel layer or along the sides of the basin. Coarse aggregate and filter fabric can also be limited to an envelope around the undedrain (e.g. perforated pipe). Underdrain pipes can be directed to storm drain pipes or nearby channels if sufficient head is available. Overflow will typically occur during relatively large storm events. Therefore this type of system must be designed to overflow to a conventional storm drain structure such as a channel or a curb and gutter system, or to another downstream storm water treatment system such as a vegetated swale or an extended detention basin.

Figure 3-2□:□ioretention basin in□or□orated into a traffi□ □al□ ing feature with inflow and o□erflow through □urb □uts

3□3□□ □ands□a□e □etention

Description

Landscape detention, also known as bioretention basins or porous landscape detention, consists of a low-lying vegetated area underlain by a sand reservoir and an underdrain system. If underlying existing site soils allow for a significant amount of infiltration (minimum 0.5 in/hr (120 min/in)), an underdrain pipe may not be needed. This type of BMP utilizes a combination of soils and plants to remove pollutants from storm water runoff through physical and biological processes. A typical landscape detention design includes a depressed ponding area, a topsoil or mulch layer, an engineered soil mix of peat or leaf compost and clean sand, and a gravel sub-base layer with an underdrain system consisting of a perforated pipe in a gravel layer. A vegetated buffer strip can be added to provide pretreatment. Storm water runoff from small events passes through slotted curb or curb cuts, which slows its velocity and distributes it evenly along the length of the ponding area. Water ponded to approximately 6 inches gradually infiltrates into the underdrain system, underlying soils or is evapotranspired over a period of days. The surrounding area should be graded to divert excess runoff from large events away from the landscape detention area towards the conventional storm drain system.

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3.3 BIORETENTION SYSTEMS

Applications and Advantages

Landscape detention may be used for commercial, residential, and industrial areas. It is well suited for street median strips, parking lot islands, and roadside swales. In addition to providing significant water quality benefits, landscape detention facilities can provide shade and wind breaks, absorb noise, improve an area's aesthetics, reduce irrigation needs, and reduce or eliminate the need for an underground storm drain system. Landscape detention areas may be integrated into a site's overall landscaping. Designers may use existing natural surface depressions and swales on the site.

Limitations

- Not suitable for locations where the seasonally high groundwater table is within 5 feet of the ground surface.
- Clogging may be a problem, especially in areas with high sediment loads in the runoff.
- Freezing may prevent infiltration of the runoff.
- If located in the vicinity of active construction sites, sediment controls and fencing should be installed to prevent clogging and compaction of engineered and existing site soils from heavy equipment.

Siting Criteria

- Drainage area should be less than 1 acre.
- May be located on-line or off-line of the primary drainage system.
- Not recommended for areas with slopes greater than 20 percent.
- Layout should be determined based on site constraints such as location of utilities, underlying soil conditions, existing vegetation, and drainage patterns.
- If designed to infiltrate storm water into underlying soils, bioretention systems are considered indirect infiltration systems. Therefore apply site screening, infiltration testing, separation, and setback standards for indirect infiltration systems presented in Section 4.2.

Design and Construction Criteria

- Registered professional civil engineers and landscape architects should work together on the design landscape detention basins. Appropriate plant species can stabilize banks and increase the infiltration capacity and storm water treatment effectiveness of landscape detention basins.
- If locally available sand and gravel is typically washed with a high Ph, recycled wastewater, sand and gravel **must** be rinsed with potable water prior to installation and construction of the sand filter.
- A typical landscape detention design includes a depressed ponding area, a topsoil or mulch layer, an engineered soil mix of peat or leaf compost and clean sand, and a gravel sub-base layer.
- Curb cuts can provide entrance into new and retrofitted landscape detention areas.

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3.3 BIORETENTION SYSTEMS

- A vegetated swale or buffer strip can be added to provide pretreatment.
- The size of the landscape detention area is a function of the drainage area and the runoff generated from the area. Recommended minimum dimensions of the landscape detention area are 15 ft wide by 40 ft long.
- Areas longer than 20 ft should be twice as long as they are wide.
- A permeable filter fabric separating the bioretention system from existing site soils and the engineered soil mix from the gravel sub-base should be installed.
- To allow infiltration and prevent clogging, the filter fabric should be a woven geotextile fabric layer such as SI Corporation Geotex 117F or an approved equivalent.
- An impermeable liner should be installed in areas where existing site soils are expansive clays or if there is outdoor storage or use of chemicals or materials within the drainage area that could threaten groundwater quality if a spill were to occur.
- An underdrain system consisting of a perforated pipe in a gravel layer is typically required where the infiltration rate of existing site soils is less than 0.5 in/hr (120 min/inch).
- The gravel layer should be Class C backfill, Section 200.03.04 of the Standard Specifications for Public Works Construction (SSPWC).

The aggregate specifications noted above are from the Reno, Sparks, Washoe County, NV SSPWC and may not apply to local aggregate specifications. The City of Salinas should review the highlighted aggregate specifications that follow and insert the appropriate classifications and section numbers for the version of the SSPWC used locally, which may apply to the entire Central Coast (?). In the Truckee Meadows, this review was conducted by a local geotechnical engineering firm.

- If underlying existing site soils allow for a significant amount of infiltration (0.5 in/hr or more), an underdrain pipe may not be needed.
- Infiltration testing should be conducted at the location and bottom depth of the proposed bioretention system. A boring or test pit may be acceptable provided it is installed to a minimum depth of 5 ft below the bottom of the proposed bioretention system.
- Soils classified as type A or B may be suitable for infiltration of storm water and underdrain systems may not be necessary. (Refer to Appendix A for NRCS Soil Survey Maps of the Salinas area for a preliminary assessment of soil infiltration properties.)
- Infiltration testing may be required by the local jurisdiction to confirm infiltration rates at the site of a proposed bioretention system
- Size the landscape detention area to capture and treat the Water Quality Volume (WQ_V) using the method outlined in Section 4.5.1.
- Flows in excess of the WQ_V should drain out of the landscape detention area and flow to another treatment control or the conventional storm drain system.
- Determine the ponding depth of the landscape detention area (D_{WQV}) based on the available surface area (SA) using the following equation:

$$D_{WQV} = (WQ_v / SA) \times 12$$

Where: D_{WQV} = ponding depth of the temporary ponded water (ft)

WQ_v = Water Quality Volume using the method outlined in Section 4.5 (ft^3)

SA = Surface area of ponding area based on the length and width at the toe of the sideslopes

- Maximum recommended ponding depth is 12 inches and minimum ponding depth is 6 inches with water standing no longer than 72 hours. This prevents problems with mosquito breeding and certain plants that can't tolerate standing water.
- Planting soils should have infiltration rates greater than 0.5 in/hr (120 min/in).
- The recommended engineered soil mixture is 50-60 percent clean sand (ASTM 33), 20-30 percent peat or certified compost with a low P-index, and 20-30 percent topsoil.
- The maximum infiltration rate should not exceed 3.0 inches per hour.
- The pH of the soil should be between 5.5 and 6.5.
- Approximately 3 inches of shredded hardwood mulch should be applied to the area.
- Rule of thumb is 1 tree or shrub for each 50 ft^2 of landscape detention area.
- Plant selection and layout should consider aesthetics, maintenance, native versus non-native invasive species, and regional landscaping practices.
- Some trees should be planted on the perimeter to provide shade and shelter.

Inspection and Maintenance Requirements

- Upon installation, landscape detention basins should be inspected monthly and after large storm events.
- Inspections can be reduced to a semi-annual schedule once the landscape detention basin has proven to work efficiently and properly and vegetation is established.
- A health evaluation of trees and shrubs should be conducted biannually.
- Pruning and weeding as necessary.
- Mulch replacement generally required every two to three years.
- If ponding is observed for seven (7) consecutive days or longer from May through October (the local mosquito breeding season), cleaning of the underdrain system or replacement of engineered soils may be required.
- Key maintenance areas include inlet areas, under drain, and overflow structures.
- If a spill occurs and hazardous materials contaminate soils in landscape detention areas, the affected materials should be removed immediately and the appropriate soils and materials replaced as soon as possible.

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3.3 BIORETENTION SYSTEMS

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U.S. EPA Stormwater Technology Fact Sheet: Bioretention http://www.epa.gov/owm/mtb/biortn.pdf

U.S. Department of Transportation, Federal Highway Administration, Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring, Fact Sheet – Bioretention. http://www.fhwa.dot.gov/environment/ultraurb/3fs3.htm

Urban Drainage and Flood Control District (UDFCD), 1999. Urban Storm Drainage Criteria Manual, Volume 3 – Best Management Practices. Denver, Colorado.

Figure 3-2: Landscape Retention at the edge of a Parking lot.

Figure 3-3: Landscape Retention in a Parking lot island with turf and Plants.

3.3 BIORETENTION SYSTEMS

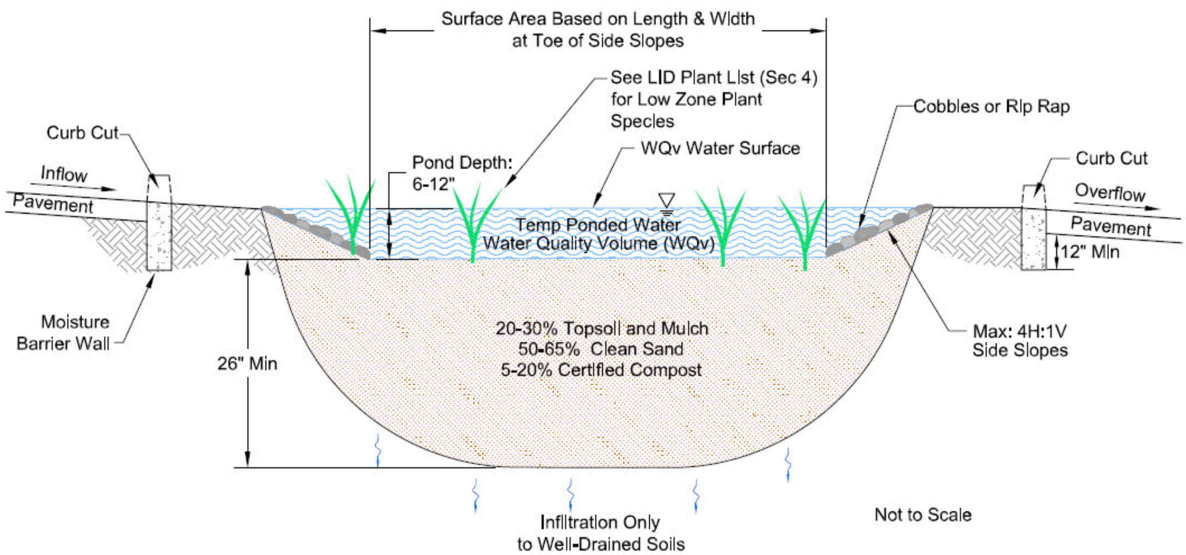

Figure 3-31: Schematic of an infiltration only bioretention basin sited on well draining soils (infiltration rates of 0.5 in/hr or greater)

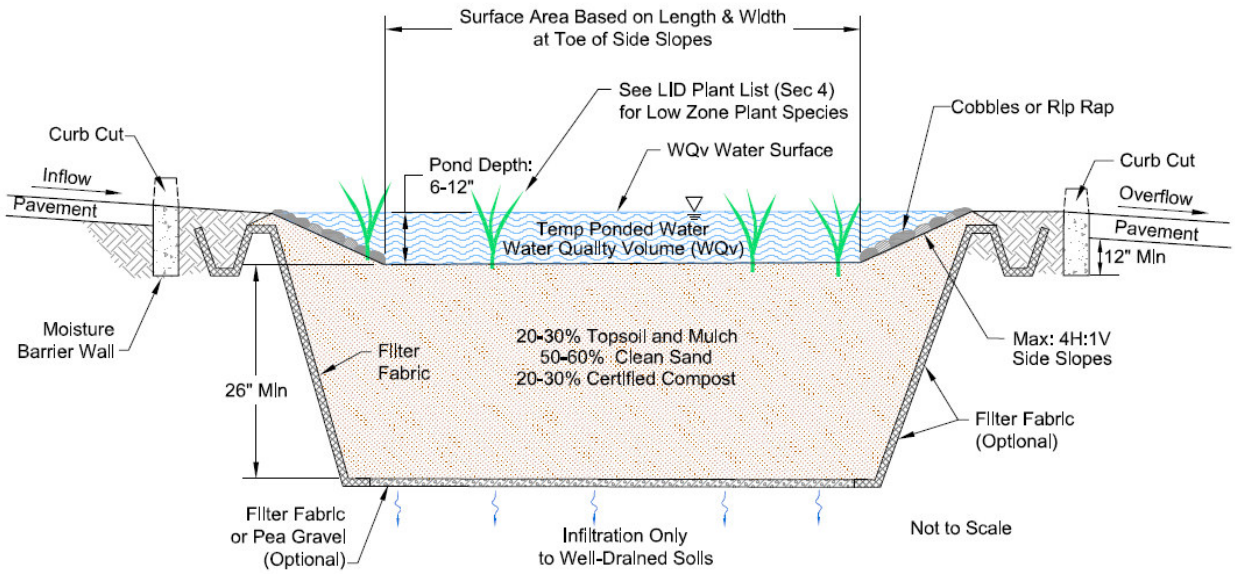

Figure 3-32: Schematic of an infiltration only bioretention basin sited on well draining soils (infiltration rates of 0.5 in/hr or greater) with an optional filter fabric liner installed along the basin walls.

3.3 BIORETENTION SYSTEMS

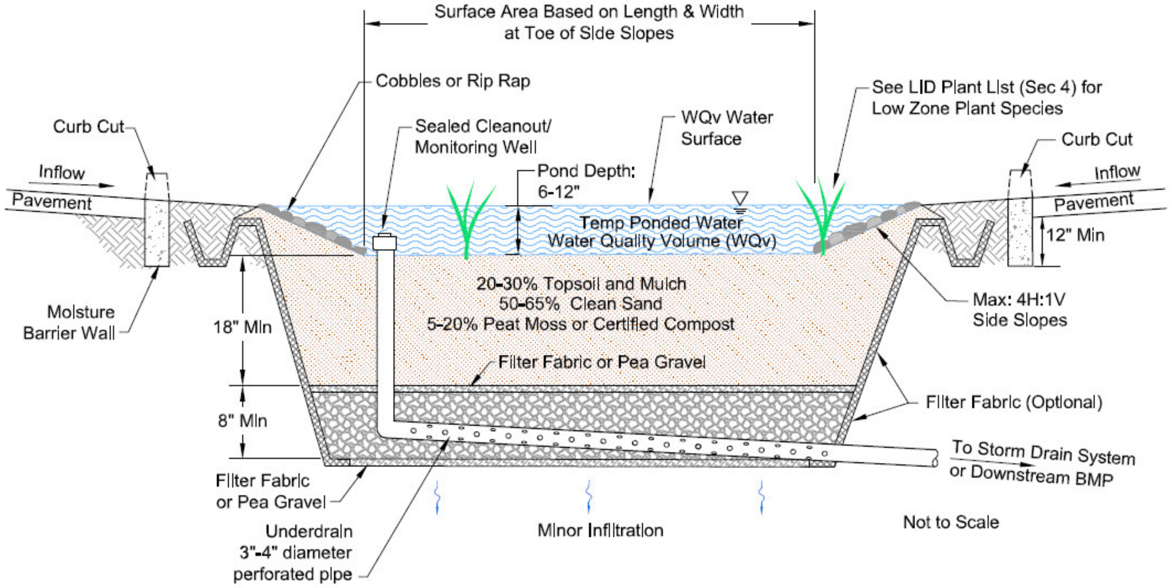

Figure 3-33: Schematic of a bioretention basin sited on poorly drained soils (infiltration rates of less than 0.5 in/hr) with an underdrain system and optional filter fabric liner installed along the basin walls.

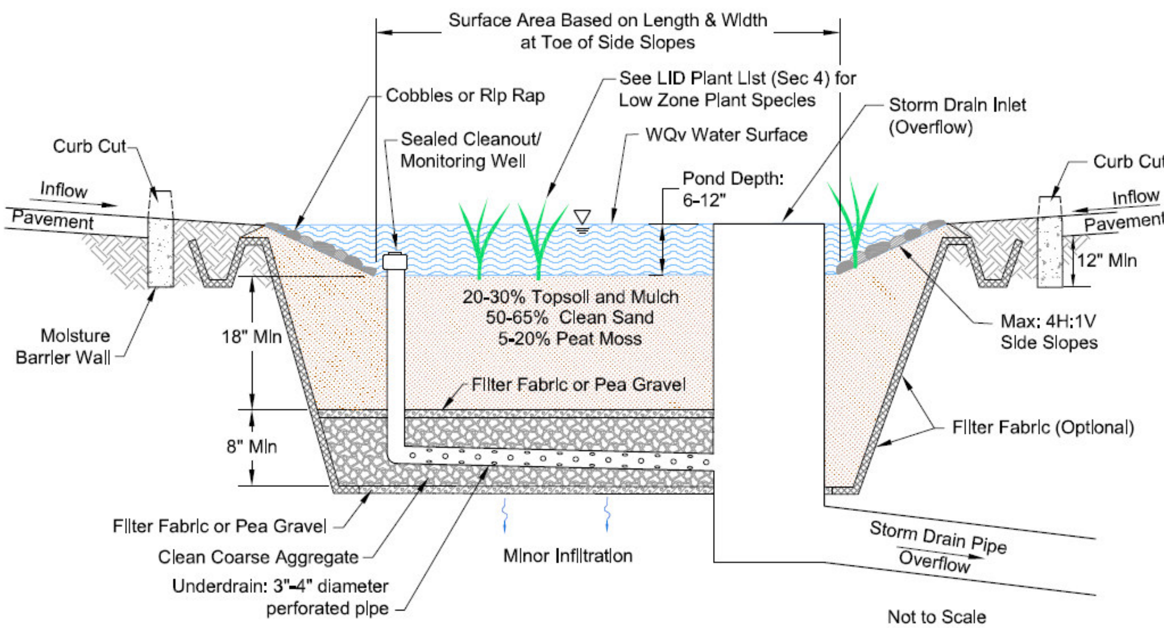

Figure 3-34: Schematic of a bioretention basin sited on poorly drained soils (infiltration rates of less than 0.5 in/hr) with an underdrain system, a storm drain inlet located inside the basin, and an optional filter fabric liner installed along the basin walls.

3.3 BIORETENTION SYSTEMS

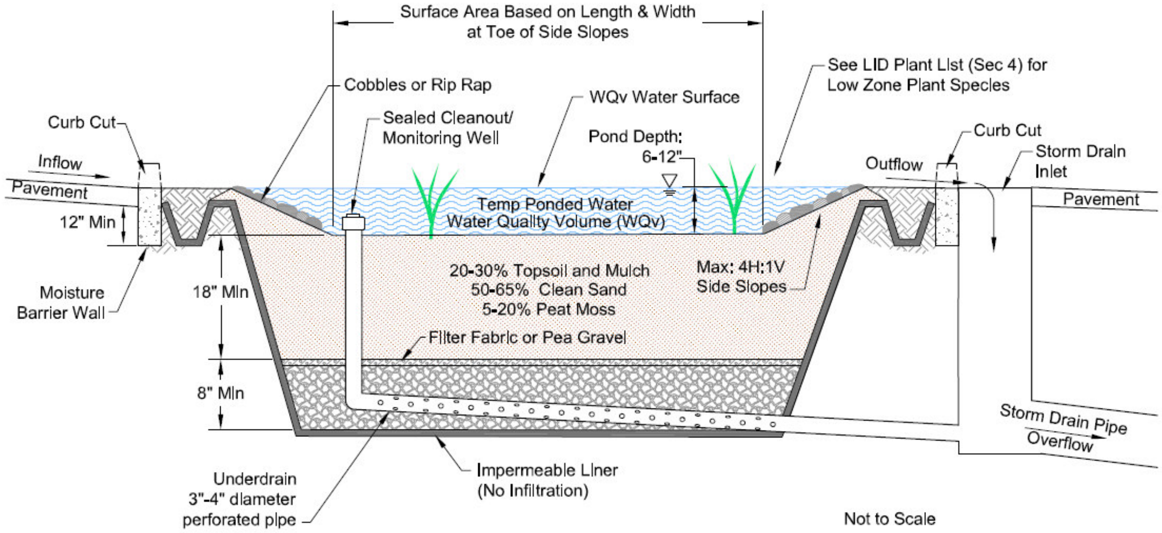

Figure 3-35: Schematic of a bioretention basin sited on expansive clays with an impermeable liner, an underdrain system, and a storm drain inlet next to the basin.

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3.3 BIORETENTION SYSTEMS

3□3□□ Tree □ox Filters

Text to be developed – XX – include language that tree box filters designed similar to Filterra may encounter patent right infringement issues.

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